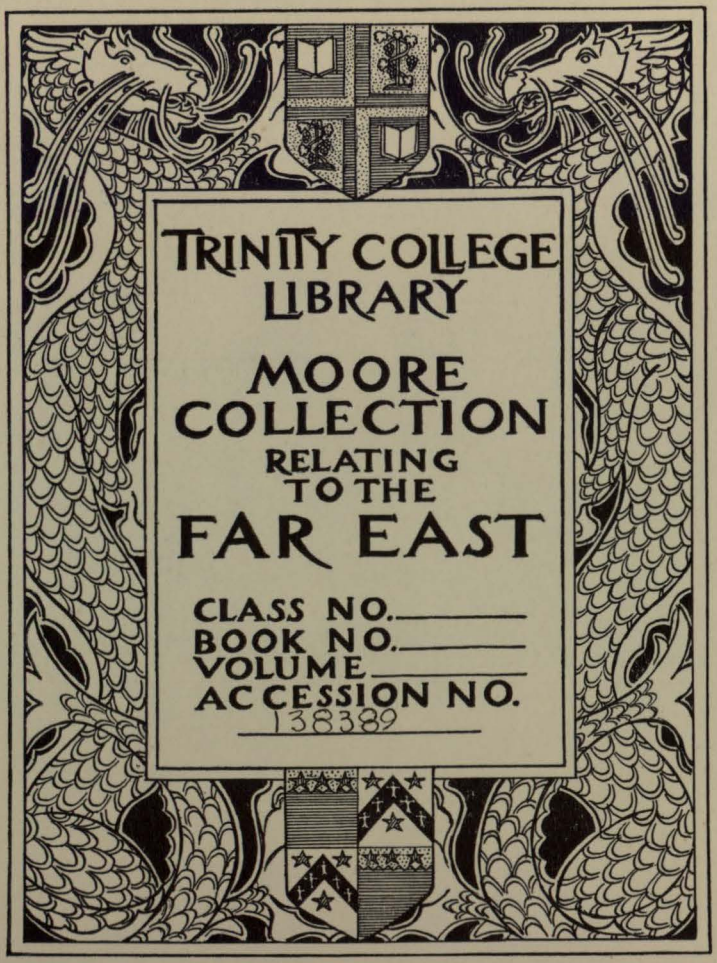
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Tung Oil and International Market

by
Lo Chen-Chuan
Kao Ping-Shu

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Tung Oil and International Market

LO CHEN-CHUAN
and
KAO PING-SHU

Sino-International Economic Publications: No. 6

ORIENTALIA, INC., New York

4216

SINO-INTERNATIONAL ECONOMIC RESEARCH CENTER

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(1) To undertake research and study for the better understanding of Chinese economic conditions and of economic relations between China and other countries;

(2) To collect, analyze and preserve statistics and other materials for the promotion of economic development in China and for the advancement of economic relations between China and other countries;

(3) To promote and organize discussions and exchange of information on Chinese and international economic and business problems;

(4) To publish pamphlets, reviews, periodicals and books in connection with the foregoing activities.

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Published by

SINO-INTERNATIONAL ECONOMIC RESEARCH CENTER

Distributed by

ORIENTALIA, INC., New York

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PUBLISHED SEPTEMBER, 1948

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138389

Printed in the United States of America

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CHAPTER I

TUNG OIL PRODUCTION IN CHINA

1. *Story of "Tung"*

Tung is the Chinese word for heart, applicable because of the large heart-shaped leaf of the mature tree. Tung was first mentioned in connection with paint in the "Book of Poetry", a collection of Chinese folk songs edited by Confucius over 24 centuries ago. The trees are handsome, very hardy, and fast-growing, about twenty feet tall, and characterized in spring by a profusion of clusters of pale pink blossoms. The fruit appears as a small green ball, almost immediately after the flowering period, and, when mature in September or October, is oval, two to three inches in diameter, and covered with a hard dark brown hsuk. Each fruit contains three to seven hard brown seeds bearing the white meat from which tung oil is pressed.

Tung trees are sub-tropical, and consequently peculiar to southern China. They thrive on very poor rocky soil, in regions between 26° to 34° north latitude and in hilly country up to 2,500 feet in altitude, particularly in the upper reaches of the Yangtze valley in China. Good drainage, adequate rainfall and a sufficiently cold winter to afford the trees a frost-free resting season, complete the climatic specifications. Tung trees are an excellent complement to the minute system of agriculture in China, as they flourish on hillsides and in mountainous areas.

Tung oil, or China wood oil, is really extracted from different species of the same family, Euphorbiaceae. The former is from the Aleurites Fordii, regarded as the harder and more important of the two species, usually known as the tung tree,—growing in the upper valley of the Yangtze River, and yielding an excellent quality oil in large quantity. The growth of this species is more widespread. The wood oil is derived from the species of Aleurites Montana, known as the wood oil tree, or "Mou-Yu", a popular term in Canton and Hongkong,—growing in southern China, particularly in the Kwangsi, Kwangtang and Fukien provinces. The Montana blossoms comparatively earlier and the tree is considerably larger when it is mature than the other species; in comparison, it has a slower growth but a longer productive life span. The Kwangsi province has attempted at various times to suppress the cultivation of the unsatisfactory wood oil trees, and replaced them with more favorable tung trees.

Tung oil is a thick, semi-solid substance, varying from pale yellow to dark brown in color. The fruit of the tung tree ripens in September or October, depending upon the climate of the locality. Chinese farmers generally knock off the fruit prematurely, not allowing it to fall naturally to the ground at full maturity, thus lessening the amount of labour required for weeding the grass, permitting free collection of fallen seeds, and reducing loss through thievery. Manufacture of the oil involves three operations, as follows:

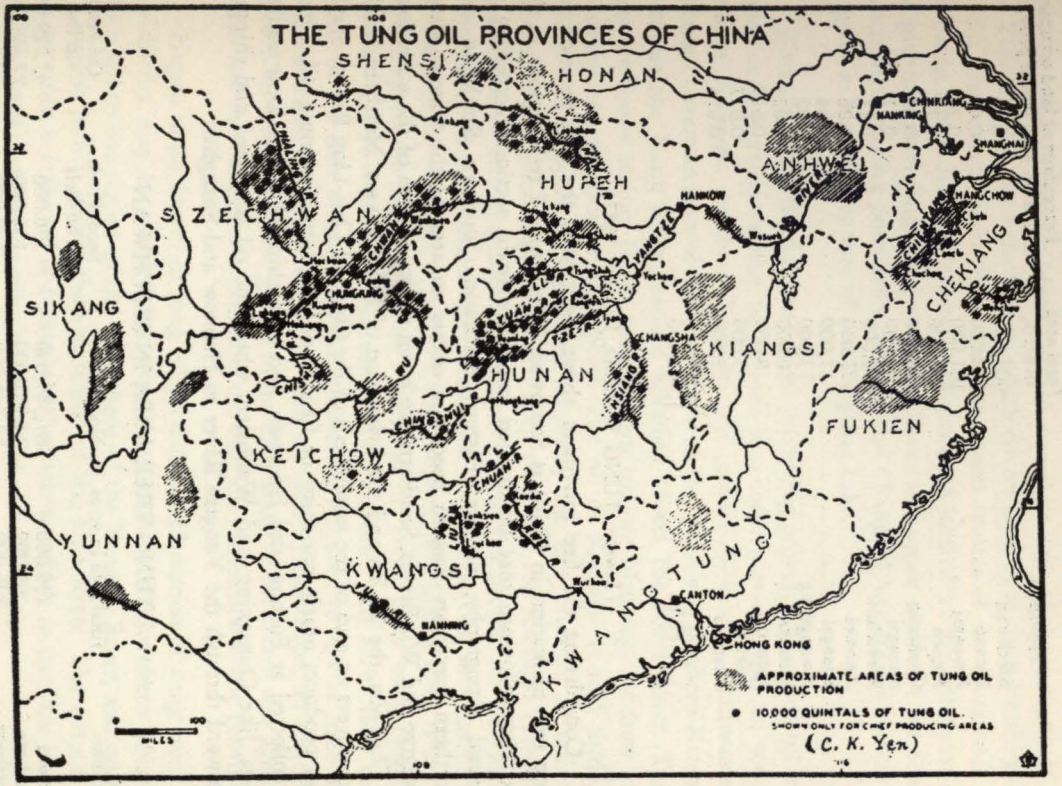
The method employed by local producers in removing the husks is crude although effective. First the nuts are stirred in a large iron pan over a wood fire until parched. This causes the husks to open, permitting free extraction of the seeds. Another method employed for seed removal is to gather the nuts prior to full maturity and cover them with straw or grass, causing fermentation in the thin fleshy part of the fruit, and thus allowing the nuts to be easily extracted. The latter method is more time-consuming, but it conserves labour and fuel.

The seeds on extraction from the husks, are ground into a fine meal in stone mortars. These mortars are rather large, holding several bushels of nuts and resembling a stone trough, made of several sections, and about three feet in diameter. When the nuts have been placed in the mortar, they are ground by a heavy stone roller propelled by ox or horse. Properly ground, the meal is collected in an old-fashioned press and compressed with wedges, to increase the effect of the heavy stone piles on top of the press. The meal is usually heated or steamed before insertion into the press to facilitate extraction of the oil. Sun-curing the kernels before crushing will produce a lighter oil, while subjection to a high artificial heat will make it much darker.

The oil on being removed from the press is sieved or strained through a series of coarse grass cloth or silk-filters. Finally it is packed in baskets or crates woven of bamboo, lined with grass cloth or paper, and well sealed.

2. *Distribution of Producing Areas*

Tung trees are abundant and grow luxuriantly in China, especially in the upper reaches of the Yangtze valley and the adjacent areas. This area involves five major contiguous geographic regions, the Szechwan Basin, the South Yangtze Hills, the Central mountains, the southwestern plateaux, and the southern coastal hill region, and covers no less than fourteeen provinces, namely, Szechwan, Hunan, Kwangsi, Hupeh, Chekiang, Kweichow, Shengsi, Anhwei, Kwangtung, Honan, Kiangsi, Fukien, Kiangsu, and Yunnan. It includes an area of about 687,000 square miles, the first five of these being


THE TUNG OIL PROVINCES OF CHINA
SHENSI
HONAN
HUPEH
ANHWEI
SZECHWAN
SIKANG
HUNAN
KIANGSI
CHEKIANG
FUKIEN
KEICHOW
YUNNAN
KWANGSI
KWANGTUNG
HANKOW
CHANGSHA
NANKING
SHANGHAI
HANGCHOW
CANTON
HONG KONG
NANNING
APPROXIMATE AREAS OF TUNG OIL PRODUCTION
10,000 QUINTALS OF TUNG OIL.
SHOWN ONLY FOR CHIEF PRODUCING AREAS
(C. K. Yen)

provinces and contributing about 85 per cent of the total oil production in China. According to the estimates of oil experts, the table shows China's tung crop listed by provinces:

TUNG TREE AREA IN CHINA

Provinces	Total area in acres	Percentage of land occupied compared with whole province
Szechwan	907,000	0.90
Hunan	292,000	0.43
Kwangsi	161,000	0.29
Hupeh	108,000	0.24
Chekiang	93,000	0.34
Shengsi	54,000	0.11
Kweichow	50,000	0.11
Anhwei	21,000	0.06
Kiangsi	17,000	0.04
Kwangtung	13,000	0.02
Yunnan	10,000	0.02
Honan	8,000	0.019
Fukien	5,000	0.017
Kiangsu	3,400	0.014
TOTAL	1,742,400	

(*Source*: TUNG WORLD, January, 1947)

Considering the five provinces above mentioned the best location for tung tree plantation in China is Szechwan. The tung oil tree regions in the Szechwan province may be divided into three main sections, according to natural topography, namely, Eastern Szechwan, Southern Szechwan and Northern Szechwan. Eastern Szechwan covers an area of the watersheds of Yangtze and Wu Rivers. Southern Szechwan covers an area of the watersheds of Chin-Sha, the Ta Tu and the lower part of Ming Rivers. Northern Szechwan covers an area of the watersheds of the Chu and Chia-Ling Rivers. Szechwan produces nearly one-third of China's annual output of tung oil, which is collected at Fuchow and Hochuan, and then shipped to the local trading ports, like Chungking, and Wanhsien, where the oil is refined and shipped eastward through the Yangtze River to Hankow and Shanghsi.

TUNG TREE AREA IN SZECHWAN

Sections	Total area in acres	No. of trees	Seed. Prod. in bushels	Oil Prod. in lbs.
Eastern	230,000	67,349,000	570,000	47,229,000
Southern	81,000	15,531,000	154,000	27,406,000
Northern	596,000	83,736,000	428,000	39,081,000
TOTAL	907,000	166,616,000	1,152,000	113,716,000

(*Source*: TUNG WORLD, Jan., 1947)

Hunan ranks second in tung oil production. Located in the heart of China, it enjoys the best transportation facilities, lakes and rivers linking it to Chungking on the north, railways to the south and east, and highways to the west. The tung oil region in Hunan province may be divided into three districts, namely: western Hunan, which covers an area of the watersheds of the Yuen Rivers: northern Hunan, which covers an area of the watersheds of the Su River: and eastern Hunan, which covers an area of the watersheds of the Siang River. Important producing areas are located in the northwest of the province extending along the Yuen River and upper course of the Siang River: local trading ports are Changteh and Changsha, and thence the oil is shipped to Hankow by way of the Tungting Lake.

Kwangsi is the third important oil producing province. The tung oil tree region in this province may be divided into three portions, that is: southwestern Kwangsi, northern Kwangsi and eastern Kwangsi. Southwestern Kwangsi covers an area of the watersheds of the Yu River, northern Kwangsi covers the Hang River, eastern Kwangsi covers the Kwei River. Tung trees are found mainly in the southwestern section; Nanning, Liuchow and Wuchow are the local trading ports. The oil of Kwangsi is sold through brokers and shipped to Hongkong. Probably the first province to enforce widespread compulsory plantation of tung trees was the Kwangsi Province. As a means of encouragement and inspiration to the people, the Provincial Afforestation Station under the Reconstruction Bureau of the Provincial Government of Kwangsi, sponsored the planting of 543,424 tung trees. In 1936, Regulations Governing the Plantation of Tung Trees were promulgated by the Provincial Government, which provides that each *tsuan* consisting of ten chia or one hundred families be required to sow at least one hundred catties of tung seeds. Under such compulsory plantation, no less than 85,269,746 tung trees were grown in the early stage of the recent war against Japan, and this furthered appreciably the tung oil production in the province.

Hupeh ranks fourth in tung oil production. Plantation of tung trees in this district may be divided into two areas, namely, southwestern Hupeh, which covers the region of the watersheds of the Yangtze River, and northern Hupeh, which covers the watersheds of the Han River. The output of this province is collected at Ichang and Laohokow, which in turn are linked with Hankow, the leading tung oil market of central China.

The fifth principal producing province is Chekiang, with producing areas located along the valley of the Chien-Tang River, and Hanchow and Wenchow as the local collecting centers. The tung oil trade in Chekiang was

most active during 1939, due to the facilities afforded by coastal shipping connections.

In addition to the five leading producing provinces, the mountainous province of Kweichow, is rather important also. Motor truck transportation acquired in wartime is responsible for this importance. The tung oil region in this province is mainly in the southern and extreme eastern portions. However, the actual production of tung fruit in Kweichow is considerably larger than the tung oil production. Due to the fact that much of Kweichow tung fruits move downstream to Szechwan, and through the Yuen River to Hunan, milling center before being crushed. Hence, a true picture of the significance of the tung growing industry in Kweichow is lacking.

The tung tree district in Shensi is located in the southern portion of the Province, in sections of the region on both sides of the Han River up to the Tsinling Mountains. The great Tsinling Mountain Range divides China into two distinct climatic areas. In the northern part, no tung trees are grown because of low temperatures or other adverse weather conditions. The oil produced in this province, is shipped by junk down the Han River to Hankow.

The province of Anhwei, although of small consequence as a tung oil area, ships practically all of its production to collecting and marketing centers in Chekiang, thus amplifying somewhat the stocks available for the leading industrial cities of the Chekiang province. Only a small share of the output of this eastern region is contributed to the Chinese export trade in tung oil.

Kiangsi province, with its producing area located in the upper Kean River, produces a rather small percentage of tung oil.

The tung oil district in Kwangtung is located along the North River and the Upper West River, chiefly along the latter. The output of this province is collected at Canton and shipped to Hongkong. During the war, Kwangtung Province was one of the few provinces planting new tung trees.

Tung trees are reported in scattered localities in Fukien Province, particularly in the vicinity of Changchow, but, as far as is known, these growths are not exploited to any degree, and the Province has not attained a significant position in either local or export trade of tung oil.

Yunnan Province, although prossessing a fair number of tung trees in the heavily forested areas to the northeast and northwest, has not become an important source of supply because of the scattered growths and the difficulties involved in transporting the oil to the export centers. Yunnan is with-

out seaport, and the only feasible means of transportation to the coast is via the France-owned Yunnan-Haifong railway.

3. *Present Producing Situation*

China reigns supreme as a producer of tung oil. In fact, as late as 1939, China was the sole commercial producer and monopolized world trade in this oil.

China's superiority in this field was due to the facts that southeastern Asia was the native home of the tung plant and its innumerable wild trees were easily accessible; the availability of the world's market for China tung oil, as a result of the negligence of other countries in discovering its value until very recently; and the plentiful supply and comparatively cheap labor in China.

Prior to 1939, China had a monopoly in the production of tung oil, because no other country produced it. It may be assumed that for the five-year period to 1938, the annual production varied rather widely but averaged 136,000,000 pounds, of which 100,000,000 pounds were exported and 36,000,000 pounds were for domestic consumption. After the outbreak of Sino-Japanese hostilities, tung oil production dropped considerably. During the war period in 1938, the Chinese government organized a state monopoly on four articles of export, tung oil being one of the four. Enforcement of the monopoly system involved the concentration of purchasing, transportation and distribution of the tung oil in the hands of government, denying those activities to private individuals or firms, and the responsibility for this execution was placed by the government on the administration of the Foreign Trade Commission. The monopoly stipulated that, when oil was brought to the collection centers, where the Foreign Trade Commission has offices or appointed purchasing agencies, it had to be sold to them within a certain length of time, or otherwise forced sales would be effected. Since Chinese government control of the oil and the prevailing low price caused a general decline in interest in the planting of new trees or in the proper care for ones already grown the trees were cut for firewood in some districts or for the planting of other food crops. During the war, the average production declined, however, to 120,000,000 pounds, of which 40,000,000 pounds were exported, and 80,000,000 pounds went for domestic consumption.

The Chinese tung oil industrialists planned on raising this average production to 180,000,000 pounds during the first five years in post-war China,

of which 120,000,000 pounds were to be for export, and 60,000,000 pounds for domestic consumption.

TUNG OIL PRODUCTION IN CHINA

(Unit: Quintal)

Province	Pre-War Average (1933-37)	War-Time Average (1937-46)	Post-War Average (1947-52) (Estimated)
Szechwan	450,000	450,000	600,000
Hunan	350,000	350,000	500,000
Hupeh	160,300	120,000	120,000
Kwangsi	150,000	300,000	300,000
Chekiang	100,000	100,000	100,000
Kweichow	50,000	80,000	80,000
Shensi	30,000	30,000	30,000
Anhwei	24,000	13,000	24,000
Kiangsi	15,000	10,000	15,000
Honan	12,000	8,000	12,000
Fukien	10,000	9,000	10,000
Other Provinces	9,000		9,000
TOTAL	1,360,000	1,200,000	1,800,000

(*Source*: CHINA MONTHLY, Apr., 1947)

The price of tung oil has not kept pace comparatively speaking with that of other agricultural products, although there has been some increase. For example, before the war one picul of tung oil was equal in value to four piculs of rice and two piculs of edible oil, while today one picul of this commodity is equal in value to two piculs of rice and one picul of edible oil. Price indexes show that the price of tung oil in terms of Chinese currency has increased 2,500 percent, but prices of other commodities have increased from 6,000 to 9,000 or more times. Such a wide variation in price limits the production and movement to market of any agricultural product, especially one like tung oil, capable of being used in whole or in part by the producer. The present low price of tung oil in China makes it decidedly unprofitable for the farmer to plant new trees, or to cultivate and fertilize them. It is a fundamental principle that if a commodity is to be produced, the price it will sell for must be in relation to the labor and investment involved in comparison to the price of other commodities. Furthermore, the great importance in the difference of the present unrealistic exchange rate of Chinese national currency on the very low domestic price of export commodities, and the resulting high costs to foreign exporters, affect the tung oil export. For example, the American importer, or the Chinese exporter, possessing U. S. currency, doesn't ob-

tains insufficient Chinese money on exchange at the official rate to pay the present low prices of export products in terms of Chinese currency. This results in lessening or checking the export of tung oil. Under these circumstances, little increase in the production of tung oil for export can occur until an effective international price adjustment is made.

In China the cost of producing tung nuts is very high, and their production is unprofitable to the farmer. This is due to the small number of the trees on each farm; the widely scattered plantings within a given area; the planting of most trees on hilly land rather than on the plains or more fertile land; the resulting low yields from each tree; and the great distance from producers to mills.

Most of the tung oil in China is produced in the rough hilly areas of the west and southwest where transportation of the oil to the collecting centers is very difficult and extremely expensive. In hilly regions, the oil is transported by coolies. Adding the handling and river freight charges on steamboat-propelled junks to the collecting centers or exporting ports increases the cost considerably. An example may be cited:

> In June 1946, the price for one pound of crude tung oil was about $0.17 U.S. in Chungking, $0.24 U.S. in Hankow and $0.32 U.S. in Shanghai. This difference in price was chiefly due to the difficulties in transportation, high rates of freight, and interest for financing purchases. It is noteworthy that on account of lack of harbor facilities and prevailing high wages, the handling charges for tung oil in Shanghai amounts to three-quarters of the ocean freight from Shanghai to New York.

In addition to the high cost of transportation, the loss of oil from leakage and adulteration occurring between the producing area and the export center, mounts to a high peak, approximating 40 to 60 percent of the export value of the oil.

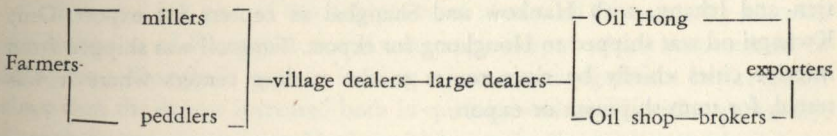
4. *Domestic Market and Exporting Centers*

Tung oil has been used for centuries in China in the manufacture of tools and furniture and, in a mixture with lime and chopped hemp, for calking junks and small boats. It was used also as a leather dressing and as an ingredient in the manufacture of soap. Burned to a soot, tung oil made a finely divided carbon which the Chinese employed in the production of India ink. Further use was found for this valuable oil in the water-proofing of papers, shoes, umbrellas, silk, pongees, oilcloth, and other materials.

Domestic outlets were formerly the primary concern in the domestic trade. Prior to 1914, consumption of tung oil in China was estimated to be at least double the amount exported. Since the World War I, foreign trade in this commodity has developed rapidly with the result of a more extensive exploitation of the trees. This changed considerably the distributive organization of this trade, and placed the domestic market in a position of secondary importance. Approximately 40 percent of China tung oil produced in China is consumed by domestic industries, and the remainder is exported, principally to the United States. The average annual domestic consumption of tung oil, during the five years from 1933-34 and 1937-38, was estimated at about 39 thousand metric tons. During the war years, domestic consumption of tung oil increased significantly owing to the shortage and higher prices for other oils. In addition to its ordinary uses, tung oil was used for lighting purposes as a substitute for kerosene in rural districts and it was also used in cities due to power shortages. According to estimation, consumption was about 60 thousand metric tons for the 1944-45 season, about 45 thousand during 1945-46, and was expected to drop to 42 thousand during the 1946-47 season with the expanding export market. However, "no matter how desirable is the foreign exchange to be realized therefrom, we must have enough for domestic consumption. North China used to be the principal consumer at home and in the event of improvement in transportation between north and south China, the amount of home consumption might exceed that of previous years". And it is expected that in post-war years, there will be more paint and varnish factories established in China, and that domestic consumption of tung oil will increase.

Although China produces a huge crop each year, there are no big plantations or extensive fields for tung cultivation. Tung oil is a side line with Chinese farmers, not providing their sole livelihood. The tung growers regard the tung nut crop as an auxiliary product, and the cash proceeds from its sale as a supplementary income. The cost of their oil is estimated in terms of barter value against rice, cotton yarn, cloth, kerosene, matches, dye-stuffs and other prime necessities. The price expressed in dollars and cents offered to them by buying agents, means comparatively little to them. Thus, tung trees are grown mostly on hillsides adjacent to farms, with the more fertile land devoted to the cultivation of food crops. Tung nuts are usually harvested after other staple crops, such as rice, corn, etc., and sold for whatever the market will bring. Tung nuts are purchased by village oil mills which extract the oil for sale. Equipment of those mills is inexpensive, and the process of oil extraction is simple. The nuts are dried in brick ovens and then ground

into powder, which is in turn baked for further reduction of moisture, and then pressed for oil extraction. Finally the crude oil is packed in paper lined bamboo baskets or wooden tubs, or the new and more preferable kerosene tins and iron drums imported by American and British mineral oil companies, in preparation for marketing. The oil is then traded, and conveyed from village to town, town to city, and city to trading centers for consumption or export. The process from the collection of the nuts to the stage when the oil is finally shipped from the trading centers, involves many intermediaries and long distances of transport. The number of hands through which the oil passes depends on the transportation facilities. Tung oil is generally sold to millers and peddlers, thence to village dealers and in turn to larger oil dealers—the intermediaries between the farmers and the oil "Hongs". The dealers travel into the interior to purchase the output from the millers, "Hongs" in turn purchasing the cargo from the dealers and selling to exporters directly—thus aiming at the profit accrued from the difference in price. They usually take advantage of the bull or bear market and speculate accordingly. Some "Hongs" appoint buying agents in the interior. The oil shops buy the oil from the dealers and sell it to exporters through brokers. In sections of China, the services of brokers are necessary for all transactions, since it is the custom that buyer and seller never meet each other. These brokers are paid periodically for their services, and in addition, receive a commission based on the value of their purchases. Before reaching the exporters, the oil goes through several intermediaries, such as: farmers, millers, oil peddlers, oil dealers, oil shops or "hongs", oil brokers and exporters. The following chart can probably show the tung oil trading relationship:



As the chart indicates, the cost of the oil is determined by the amount of intermediaries from the miller to the exporter. This all adds up to such a high percentage of the export value of the oil, that the production of tung oil is uprofitable to the farmers. They get what is left after all the others have taken their share.

Forward transactions are unavoidable due to transportation difficulties between producers and seaports, and the financial weakness of Chinese oil firms and dealers. This is especially so because of the variance in quantity on foreign orders. Inasmuch as the oil passes through so many hands, and col-

risk involved in all transactions. Agents or representatives of foreign importers avoid the risk through buying at prices quoted by home offices and lection and transportation is so complicateed, there is of necessity a certain leaving the sellers to run the gauntlet of timely deliveries by all constituent links in the chain. It is evident that Chinese oil firms are not established for direct contact with foreign markets. It seems apparent that a few cables received every morning by foreign agents dictate to the market, bringing fortune or bankruptcy to oil merchants.

Each Chinese tung area is comprised essentially of the territory drained by one of the larger tributaries of the Yangtze or the Si River. Each consists of a fairly compact area of tung tree production, a group of tung oil milling centers, and a single, and in rare cases two, major collecting and trans-shipment points. The collecting and trans-shipment points are on the downstream margin of each producing area, since the oil to be exported almost invariably moves by native boat from the milling center to the export port, or the collecting center to the export port.

No estimable success has accompanied efforts to establish modern centralized tung oil mills at Hankow, Shanghai, Hongkong, and other strategic points. Instead, innumerable small primitive local mills, scattered throughout the tung producing region, continue to account for almost the total Chinese tung oil presses.

The important trading ports in normal times were mainly concentrated at such local trading centers along the Yangtze River as Chungking, Wansien and Ichang, with Hankow and Shanghai as centers for export. Only Kwangsi oil was shipped to Hongkong for export. Tung oil was shipped from interior cities chiefly by river routes to the trading centers where it was tested, for trans-shipment or export.

In central China, Hankow is the leading market for tung oil produced in the wesetern and northern part of Hupeh, northwestern part of Hunan, and southern part of Shensi, with Ichang, Laohokow, Changteh and Changsha as its collecting centers. Transportation of tung oil from these ports to Hankow is primarily by means of large junks; at Hankow, the oil, after being reconditioned and refined, is loaded on regular river vessels and shipped to Shanghai for export.

Hankow has several significant advantages for tung oil exportation over its competitor ports: it is immediately downstream on the Yangtze from China's main tung oil producing regions, and it lies at the head of stream

navigation for large steamers during certain periods of the year. Thus Hankow became the leading tung oil trading and shipping center. Oil storing at Hankow generally requires classification, in order to bring it up to desired export quality. During the winter months, the tung oil is generally shipped by freighter to Shanghai for loading to tankers, but in summer, ocean steamers come direct to Hankow for loading.

Hankow tung oil is distributed to other cities for local consumption and also to foreign countries. Hankow's exported quantity has had a downward trend from 1913 to 1930; on the other hand, the general trend for exported value is upward. This means an advance in price with a decreased foreign demand for oil from Hankow. The cause for the decrease in quantity is the diversion of trade. The exporters will not buy the product in Hankow, but they appoint buying agencies in the interior producing districts and send their purchases directly to Shanghai for export. During the Sino-Japanese war period, owing to the fact that Shanghai was occupied, Hankow played a more important part again. However, in China's tung oil market, Hankow constantly maintains its leading position.

TUNG OIL EXPORT FROM HANKOW AND SHANGHAI

(Unit: Short ton — 2,000 lbs.)

Ports	1936-37	1938-39
Hankow	60,460	39,330
Shanghai	78,970	5,600

(*Source*: TRADE REPORT, China Veg. Oil Corp., 1939)

Shanghai is a port of trans-shipment of almost all Chinese tung oil, with the exception of Kwangsi's and Kwangtang's output which concentrated in Hongkong. Shanghai's exports in tung oil were not significant before 1926; since then the export increased both in quantity and in value. Comparatively, Shanghai's superiority over Hankow is due to its financial strength and the numerous foreign merchants represented there. The prime determinant, however, is that Shanghai is the seaport itself; foreign exporters will surely effect their purchases more conveniently there than in the interior. Since the inception of the war in 1937, Shanghai has not regained her former pre-war position. Many Shanghai dealers directed their interests to other profitable channels. But now, the Shanghai tung oil situation is establishing Shanghai as a leader in China's market.

Hongkong is an important tung oil trading and shipping port of south China. Although oil produced in Kwangsi province is ultimately collected at

Wuchow and Canton, the actual sales for export shipment are customarily transacted through Hongkong. Considerable variations occur, however, from year to year in the relative amounts of tung oil shipped through Hankow and Hongkong. This is a reflection of comparative transportation, political and military conditions in the Yangtze and Si River basins. Unsettled political or military conditions in an area tributary to a port, causes the diversion of exports to another port. This is emphasized by the fact that a distance of less than one hundred miles separates the tributaries of the Yangtze from the head waters of the Si River. Hankow's tung oil exports were reduced to insignificance by the Sino-Japanese war operations, causing Hongkong exports to increase 300 percent in a single year.

TUNG OIL EXPORT FROM HONGKONG

(1936-40)

	(Unit: metric tons)			(Value CN$)		
Year	Total	Hongkong	Percent	Total	Hongkong	Percent
1936	86,738	6,016	6.9	73,378,657	2,934,674	4.0
1937	102,978	21,236	20.6	89,845,563	16,084,324	19.0
1938	69,577	55,810	80.2	39,237,038	30,960,669	78.9
1939	33,501	30,066	85.9	33,614,794	30,424,319	90.5
1940	23,248	15,348	66.0	56,358,859	24,757,776	56.0

(*Source*: TRADE REPORT, China Veg. Oil Corp., 1940)

The decrease in the quantity of tung oil exports to Hongkong was especially noticeable, being 15,348 tons in 1940 as against 30,066 tons in 1939, or a reduction of 49 percent. The reduction may be attributed, first, to the reduction of China's total exports of tung oil, and secondly, to the routing of tung oil exports from the port of Rangoon, although this had only a slight effect. Thus the portion of tung oil shipments to Hongkong from China was reduced to 66 percent, as compared with 85.9 percent during 1939.

CHAPTER II

TUNG OIL EXPORT TRADE OF CHINA

1. *Importance as an Export Commodity*

Tung oil is one of the prominent industrial raw materials involved in world trade. For many years, tung oil played the most important role in China's exports, primarily because this commodity occupied the leading position pre-war among the staple items of China's export trade, and also because tung oil was one of the most important products available to China to replenish her foreign exchange reserve for her currency or obtaining loans from foreign countries.

CHINA'S EXPORT AND TUNG OIL EXPORT

(1931-40) (Value CN$)

Year	Tung Oil Export	Total Export	Tung Oil Export to Total Export
1931	$31,808,287	$1,416,962,868	2.24
1932	23,161,233	767,535,334	3.10
1933	30,261,269	611,827,990	4.95
1934	26,216,683	535,214,279	4.90
1935	41,582,879	575,809,060	7.22
1936	73,378,654	705,741,403	10.40
1937	89,845,563	838,255,705	10.71
1938	39,237,038	762,641,058	5.14
1939	33,614,794	1,027,246,508	3.11
1940	56,357,844	1,970,120,647	2.87

(*Source*: THE TRADE OF CHINA, Statistical Series, 1931-40, Pub. Maritime Customs of China)

Practical demonstrations of the valuable properties of the oil, increasing knowledge of proper technical procedure, and adaptation of the product to new industrial applications in the foreign markets, have been equally responsible for the notable progress achieved in the development of China's export trade for this commodity. Tung oil's major utility is in the paint and varnish, linoleum and oilcloth and printing-ink industries. The use of tung oil has

expanded materially, although world consumption has not as yet reached its saturation point.

In the thirteenth century, Marco Polo, returning from China, described the marvelous "wood oil" being used by the artisans of Cathay in the production of their fine enamels and lacquers as follows:

> "The Chinese take some lime and chopped hemp, and these they knead together with a certain wood oil and when the three are thoroughly amalgamated, they hold like any glue, and with this mixture they paint their ships."

Although the use of tung oil for ships was first known to Europe at that time, its export dates only from the year 1516, when the Portugese traders came to Kwangtung, and received from the merchants of Carthay a commodity designated as "China wood oil". Since then, navigators and traders from Europe seeking spices and other commodities, would transport tung oil back to their countries. The exporting cities were Canton and Amoy, and the quantities exported were limited.

The recent rise in China's exports of tung oil has been matched by increased imports of that commodity into the United States. It was as late as 1905 that American manufacturers first became seriously concerned with the use of tung oil. Between 1914 and 1918, tung oil afforded the American varnish manufacturers a new tool which they learned to handle very skilfully. The Englishmen, however, had not in the beginning the same incentive to change their methods, but as the special characteristics of tung oil came to be recognized, they gradually found a way to compromise between the old and new methods, and can still claim that English varnish-making practice holds its own with all newcomers. Consequently, the imports of tung oil to Great Britain have been increasing. Nevertheless, the United States still holds the most dominant position as importer and user of tung oil. Prior to the recent war, the United States annually imported between 100,000,000 and 175,000,000 pounds, representing 20 to 30 percent of her total imports from China. No other Chinese commodity is at present as valuable to this country.

The world today is constantly on the lookout for new sources of tung oil. The United States accounts for 70 percent of China's exports, the remaining 30 percent going to Europe, South America, and other consuming countries.

EXPORTS OF TUNG OIL FROM CHINA

(1935-39) (Unit: metric ton)

Year	U. S. Quantity	U. S. % of Total	Europe Quantity	Europe % of Total	Others Quantity	Others % of Total	TOTAL
1935	53,608	72.6	16,145	21.8	4,133	5.6	73,886
1936	65,445	75.5	17,526	20.2	3,767	4.3	86,738
1937	72,745	70.6	21,104	20.5	9,129	8.9	102,978
1938	43,022	61.8	15,797	22.7	10,760	15.5	69,579
1939	27,595	70.1	7,190	18.3	4,564	11.6	39,349

(*Source*: Report of the China-U. S. Agricultural Mission, 1947)

During 1947, it was reported that China's total export of tung oil was 73,653 metric tons with an aggregate value worth approximately U. S. $30,000,000. Out of these seventy-three thousand metric tons, 48,740 tons were shipped to the United States, 7,850 tons to the United Kingdom, 3,124 tons to the Soviet Union, and 2,539 tons to other countries. Prior to this year, China's export of tung oil under the Import License System in the United States, was based on the quota allocations of the International Emergency Food Board at Washington. The primary consideration of the Board is a fair allocation and distribution of essential foodstuffs and edible oils between the sources of supply and the consuming countries of the world. At the present time, however, tung oil is not under international allocation and is not included among the commodities subject to United States import restrictions.

Due to the execution of the construction program and the general shortage of other drying oil in both the United States and Europe, there is an increasing demand for tung oil in the paint and varnish industry. With all import controls removed, the United States as well as European countries may be able to receive a sizeable part of 1948's shipments. The development of paints and varnishes and similar industries in India and Australia may result in substantial markets in those countries in the future.

2. *The United States as a Leading Market*

Although the demand of tung oil had increased in all industrial countries prior to the recent war, the United States' allotment represented the largest part of the world's demand. The first shipment of tung oil to the United States was made in 1869, but it was not until 1875, with the discovery of its quick drying properties by Cloez, which even surpassed those of linseed oil,

that tung oil stepped in line as an important industrial raw material. Imports into the United States then increased, and since 1900, there has been a marked expansion. In recent years, the volume of imports of tung oil from China has grown to well over 60,000 tons a year, and it has assumed an outstanding position in China's foreign trade, occupying first place in value among commodities exported in 1939.

The rapid growth of the American paint and varnish industry, as well as the development of new outlets for tung oil in America, account for the United States' becoming the outstanding world market for this product. The most important asset of tung oil is its quick drying property. The paint and varnish industry alone consumed 120 million pounds of this oil in 1937.

Numerous important usages have developed for varnish: for the surfacing of floors and woodwork; for motor coaches and buses, automobiles and railway-car-work, for the protective coating of tin; in electrical printing; as an insulating material in the electrical industry; as a preservative covering for aeronautical parts exposed to the elements. Varnishes composed of tung oil have proven their superiority repeatedly. They have expedited work and reduced the necessity of early replacement in industrial operation and maintenance work. The demand for this oil in industrial varnish manufacture is bound to expand in the future. When incorporated into flat paints, tung oil produces a highly resistant surface of enamel-like smoothness. Applied to wood, iron, millboard, asbestos, cement, and other bases, it has been found to withstand considerable wear. Tung oil in a mixture with aluminum powder, gilsonite, asphalt, or other preservative materials, has been increasingly employed in the protective covering of ironwork, metal roofs, storage tanks and sidings.

Secondary to the paint and varnish industry as an important consumer of tung oil, stands the linoleum and oilcloth industry, which used about seven million pounds of tung oil in 1937. In the manufacture of linoleum, oilcloth, and artificial leather, tung oil is used ordinarily as a vehicle for other coating substances.

The printing ink industry consumed approximately three million pounds of tung oil during 1937, chiefly for specialty inks, such as those used in bronze printing. The manufacture of miscellaneous products in 1937 consumed about five million pounds, and 28 million pounds were listed as "unaccounted for". A portion of this latter quantity was used in the manufacture of waterproof composition for concrete; gaskets for steam pipe, pumps, and engines; and cartridge-waterproofing. During the war, tung oil was vitally important in waterproofing of shells and other munitions.

INDUSTRIAL USES OF TUNG OIL IN THE UNITED STATES

(Unit: 1,000 pounds)

Year	Paint & Varnish	Linoleum & Oilcloth	Printing Ink	Soap	Other Indus. Prods.	Total
1931	72,853	7,303	965	—	1,193	82,314
1932	59,159	7,299	713	—	778	67,948
1933	76,714	11,746	1,523	5	1,561	91,549
1934	88,184	12,854	1,660	35	3,245	105,978
1935	98,435	10,391	2,013	—	3,448	114,287
1936	94,642	7,131	2,331	2	3,769	107,875
1937	105,731	7,198	2,762	—	4,687	120,378
1938	78,310	4,131	2,084	—	2,890	87,415
1939	82,307	3,763	2,105	—	2,545	90,720
1940	54,611	2,064	1,728	—	654	59,057
1941	48,825	1,896	2,960	—	327	54,008
1942	10,896	82	255	—	597	11,830
1943	9,667	—	17	—	2,363	12,047
1944	8,084	—	27	—	1,998	10,109
1945	16,939	2,337	156	—	2,137	21,569
1946	25,458	104	521	—	2,879	28,962

(*Source*: Bur. of Agric. Economics, U. S. Dept. of Agriculture.)

The consumption of tung oil in the United States has declined drastically since 1937. In that year, tung oil accounted for 17.3 percent of the total weight of fats and oils used in the drying industries, as against 1 percent in 1944. This decline in consumption occured not because of any lack of demand, but mainly due to a radical reduction of supply.

Ever since the first recorded shipment of tung oil to the United States—138,635 pounds, valued at $53,641, and brought in by Clipper Ship from China in 1869—American tung oil consumers had been dependent upon foreign supplies, although some Chinese oil reached the United States indirectly through other hands. Before this, the oil was imported into the states for experimental purposes. The actual imports for consumption beginning in 1934.

The United States imported 175 million pounds of tung oil in 1937, 159,329,562 pounds of it from China, indicating a steady increase through the years. The United States normally takes approximately 75 percent of China's tung oil exports, but with the outbreak of the Sino-Japanese war in 1937, acute transportation difficulties developed, and exports of tung oil from China suffered a drastic decline. The following year, only 107 million pounds were exported, and the year after 79 million pounds. By 1942 imports of tung oil to the United States had fallen as low as eight million pounds; by 1944, they were down to less than two million pounds, and most of that amount came from the Argentine rather than from China. Of the 1,770,585

pounds imported in 1944, only 31,536 came from China. The 339,473 pounds imported in 1945 came chiefly from Argentina and Brazil. However, the next year, 1946, China exported 35 million pounds to the United States, almost 97 percent of this country's import during that year. There was in 1947 a marked improvement in the trade, as evidenced by the fact that 121 million pounds, representing 99.59 percent of total United States imports were from China.

TUNG OIL IMPORTS INTO THE UNITED STATES

(Unit: pound)

Year	Total Imports	From China	Percentage of import from China to total import
1919	53,852,595	45,363,472	84.23
1920	68,000,000	55,768,830	85.00
1921	27,000,000	23,456,475	87.00
1922	79,000,000	76,217,565	95.19
1923	87,000,000	77,930,932	89.55
1924	82,000,000	76,447,232	93.26
1925	102,000,000	98,125,282	96.18
1926	83,000,000	80,332,821	96.75
1927	89,770,000	75,043,427	83.64
1928	109,000,000	97,783,436	89.08
1929	120,000,000	109,549,217	90.12
1930	127,000,000	121,138,804	90.52
1931	81,000,000	75,632,777	93.34
1932	77,100,000	70,942,808	92.02
1933	119,000,000	112,235,931	90.43
1934	110,000,000	100,253,772	80.35
1935	120,000,000	108,338,426	80.00
1936	134,800,000	127,826,706	90.48
1937	174,884,803	159,329,562	90.09
1938	107,455,674	100,054,026	90.33
1939	78,717,634	80,543,846	89.70
1940	97,048,595	90,700,023	93.50
1941	43,800,457	43,708,295	99.77
1942	8,268,923	8,245,533	99.75
1943	67,893	1,623	2.40
1944	1,770,585	31,536	1.79
1945	339,473	———	———
1946	36,206,762	34,928,466	96.49
1947	121,564,669	121,105,173	99.59

(*Source*: Compiled from U. S. Dept. of Agriculture)

The entire American output of tung oils was commandeered for use by the armed services during the war years, due to its essential nature as a strategic commodity. As a result, the normal American outlets were forced to adopt inferior substitutes, but these substitutes have had only a temporary influence on American demand. The above table indicating the heavy imports of tung oil, shows that American industries are rapidly reinstating this super-

ior product, and it is anticipated that tung oil will assume its normal status in the industrial market in the near future.

3. *American Tung Oil Loan*

Subsequent to the fall of Canton and Hankow during the Sino-Japanese war, the United States, with maintenance of Chinese morale in mind, suggested through its Treasury Department, that the Chinese government send a financial mission of financiers and businessmen to approach the United States Congress in 1938-39 relative to a possible loan to China.

The mission was composed of China's Chief Foreign Trade Commissioner and two financial and commercial experts. At the first assembly, they were convinced that an immense political loan was unlikely, and were detailed on a strictly commercial—a loan based on China's ability to pay in terms of natural resources. It was an established fact that China had a number of natural resources not being importantly nor sufficiently produced in the United States, particularly tung oil, tin, tungsten, and hog bristles. The country was in a state of disruption at the time and it was likely that, as the war progressed, the trade would suffer a greater disruption, further weakening China and far from helping the United States. That trade could be maintained between the two countries was China's argument for the continuance of foreign exchange, with which she would in turn buy war materials in the United States; and at the same time the United States' requirements of Chinese raw materials would be fulfilled. Therefore, a loan from the United States was needed to accelerate the trade. The mission proposed to organize two companies to handle the business—one in the United States to sell Chinese products and buy U. S. manufactured goods, the other in China to develop the industry and deliver the raw materials. It was suggested that the first loan be based on tung oil, China's most important product in the United States trade.

China agreed that the proceeds of such a loan be turned over to the proposed company located in the United States, rather than directed to the Chinese government, and that the records of this proposed company be available for U. S. government inspection at all times. In agreeing to use half of the proceeds of every sale of tung oil for regular payments on the loan, China was to keep the loan alive and the credit good, and at the same time, have the other half to purchase additional United States goods or munitions, if the Chinese government saw fit to do so. At that time, the mission had no

difficulty proving that China could deliver the tung oil. The Japanese were busy consolidating gains in northern China, and the coast of southern China was relatively open, although Canton had fallen—and the Indo-Chinese railway, from the province of Yunnan to the French Indo-China port of Haiphong, provided a sure outlet. Then again, if anything were to happen to Haiphong, China could keep the trade moving over her new Burma road—over the mountains to Lashio, a railhead of the port of Rangoon in British-controlled Burma. Thus, the tung oil loan was granted in December 1938 by the Export-Import Bank, for the sum of U. S. $25,000,000.

In New York City, the Universal Trading Corporation was established, and in Chungkung, China, the Foo Shing Trading Corporation. The Universal Trading Corporation had one class of common stock, $500,000 worth of it, entirely owned by the Chinese government. Since its formation in October 1938, Universal has sold 41 million pounds of tung oil, and the Chinese government has purchased some $32 million worth of machinery and goods in the United States. At the end of 1939, these items, distributed in their proper categories, were as follows: automotive purchases, topping the list—$4,328,000 for trucks, $87,000 for motorcycles, $518,000 for mobile repair and machine shops, and over $1,000,000 for tires—some $6 million surplus, including all items. Universal had also bought $4,224,000 worth of gasoline, kerosene, fuel oils, and lubricants; another $1 million had gone into telephones; $626,000 into radios; $1,500,000 into iron and steel shapes and specialties; nearly twice that much for aluminum, copper, brass and other metals in the non-ferrous group; over $425,000 for khaki cloth; $1,175,000 for cotton blankets; $725,000 worth of a wide variety of chemical, drugs, and surgical instruments; $650,000 in road machinery and construction materials; and nearly $200,000 for general machine-shop equipment.

On the selling side, Universal has had to solve some complex problems. The corporation, admittedly set up to receive all the tung oil that China could ship, had to prove to the American paint and varnish industry that it was in no way effecting a monopoly to charge as much as the traffic would bear. Since tung oil is a necessary ingredient for that industry, there was good cause for the industry to fear a squeeze. Universal tried to convince the industry that they intended to get a reasonable price for the oil, but were too fearful that substitutes would cut into the tung oil market if tung oil prices were raised too high.

The task of collecting and exporting tung oil was carried on by Foo Shing Trading Corporation, organized in China, at the same time that

Universal was in process of formation. Foo Shing delivered 41 million pounds of tung oil, worth more than $8,745,000 in the first two years; that was used to pay off nearly $4,700,000 in interests and capital on $20,840,000 borrowed on the $25,000,000 tung oil loan. When China's ports were occupied by Japan and China's own counter-blockade was in effect, Foo Shing handed over the job of gathering small quantities of tung oil previously collected by village traders on commission. In addition it was necessary for Foo Shing to collect tung oil directly from the farmer; but, as time progressed and the corporation continued to offer a steady market at a fair price, the traders gradually went back into business. During wartime, Foo Shing's principal job was to provide transportation over the difficult, unnatural trade routes that war made necessary.

The American tung oil loan, according to O. C. Lockhart, "was unconditionally guaranteed by the Bank of China, and the Universal Trading Corporation agreed to apply 50 percent of the net proceeds of tung oil imported and sold pursuant to the Foo Shing contract to the repayment of its notes to the Export-Import Bank. The notes were to be repaid not later than Jan. 1, 1944, and bore interest originally at 4½ percent. The Bank reduced the rate to 4 percent on June 25, 1940. The amount of the credit utilized was $22,000,000 and this sum plus interest was repaid in full on March 30, 1942, out of the proceeds of the sale of tung oil from China. The remainder of the credit, namely U. S. $3,000,000, was cancelled on December 11, 1943."

4. *Exports to Other Countries*

The United States market for tung oil is vastly more significant than the European market. Several factors are involved in this unusual situation: the existence of extensive flaxseed acreages in Europe and the strong position of the linseed oil industry there have made for many years made the entry of other drying oils difficult, regardless of their qualifications; the relatively low purchasing power of the average European buyer of varnishes and paints has forced him to remain content with the inferior, but somewhat cheaper linseed oil products; the conservatism of the average European manufacturer has caused him to hesitate in changing his formula to use a relatively new and untried product such as tung oil, and the reluctance of European countries to become dependent upon an essential raw material which is available only from a single distant source, which might become inaccessible during wartime, has retarded the substitution of tung oil for linseed oil.

The leading European outlet for tung oil is Germany, because of its highly developed paint and varnish industry. The United Kingdom ranks second in Europe, France is third, then Denmark, Italy and the Netherlands in their respective order. China tung oil moves to few places beyond Europe and the United States, due chiefly to their lack of industrialization. Japan is the only other significant purchaser worthy of mention.

The extensive manufacture of paintings, varnishes, linoleum, oilcloth, and other products employing tung oil, establishes Germany as the most important European consumer. Of course, China's export statistics do not indicate Germany's prominence, since a considerable share of the tung oil enters that country from the Netherlands, Great Britain, and France. Exports of tung oil direct to Germany are as follows:

EXPORTS OF CHINA TUNG OIL TO GERMANY

Year	Quantity in picul	Value in CN$
1931	27,544	1,060,947
1932	19,336	565,154
1933	14,375	603,294
1934	22,495	999,733
1935	28,933	1,787,412
1936	42,957	4,226,223
1937	42,811	3,806,080
1938	14,804	819,469
1939	2,841	211,011
1940		

(*Source*: THE TRADE OF CHINA, statistical series)

The German paint and varnish industry is the principal consuming channel for this oil, taking over 80 percent of the total imports annually. The following figures show the quantity and value of tung oil used in paint and varnish manufacture, as compared with the consumption of linseed and other drying oils.

CONSUMPTION OF DRYING OILS IN THE GERMAN PAINT AND VARNISH INDUSTRY

Item	Quantity in pounds	Value in U.S.$
Tung oil	12,181,000	1,977,040
Raw linseed oil	16,159,000	1,220,943
Finer linseed oil	22,125,400	1,639,898
Other drying oil	8,762,600	614,368
TOTAL	59,228,400	$5,452,249

(*Source*: Released by the German Federal Statistical Office in 1928)

The United Kingdom is the second largest market for tung oil in Europe, average consumption requirements being estimated roughly at 9,000,000 to 10,000,000 pounds annually. The discrepancy in statistical figures refers practically to every country. For example, in Britain tung oil is not shown separately in the trade returns but is included under the classification "Other vegetable oils, unrefined, not elsewhere specified". Exports of tung oil to Great Britain are as follows:

EXPORTS OF CHINA TUNG OIL TO GREAT BRITAIN

Year	Quantity in picul	Value in CN$
1931	99,672	3,834,025
1932	86,035	2,591,881
1933	45,881	1,850,368
1934	31,309	1,323,477
1935	36,551	2,117,974
1936	37,848	3,858,631
1937	36,828	3,266,431
1938	20,262	1,074,889
1939	6,238	977,288
1940	10,178	7,612,808

(*Source*: THE TRADE OF CHINA, statistical series)

The principal use of tung oil, of course, is in the varnish and paint industry, and during the years 1900-1910, British varnish manufacturers, were gradually beginning to get used to the idea that tung oil was likely to be useful. It was perhaps inevitable, that at that time pioneers should have offered this new oil as a substitute for linseed oil. This word "substitute" has a flavor of inferiority, of something commanding a much lower price, but gradually the merits of the oil came to be recognized. Nevertheless, it has been evident that, although the population of the United States is two and one-half times that of Great Britain, the amount of paint consumed per head of the population is probably 50 percent greater. This is remarkable when we consider that the consumption of tung oil in the United States is practically ten times that of Great Britain.

The import of tung oil into England had become an essential operation by 1914. During the war years, there was a great increase in the demand for tung oil, and the British were more serious in their use of tung oil post-war. However, the present consumption of linseed oil for paint and varnish manufacture in the United Kingdom is more than twelve times that of tung oil. It is expected that the use of tung oil in the British industry will probably increase more than twofold in the near future.

France ranks third in Europe as a tung oil market. Trade estimates indicate that France's consumption ranges from 3,500,000 to 4,000,000 pounds annually. A substantial quantity of tung oil imported by French consumers is purchased through agents in the major European trading ports. Paint and varnish manufacture is one of the oldest industries in France, having shown material progress since World War I, both in the extent of production and in technical methods employed. The French paint and varnish industry now supplies approximately 80 percent of the domestic requirements for such products, and purchases of tung oil should continue to expand in volume in proportion to the steady development of that industry.

EXPORTS OF CHINA TUNG OIL TO FRANCE

Year	Quantity in picul	Value in CN$
1931	15,956	606,843
1932	17,278	513,334
1933	22,453	975,137
1934	31,849	1,341,143
1935	31,154	1,779,769
1936	36,942	3,746,151
1937	37,151	3,255,074
1938	10,795	627,880
1939	50	3,600
1940	739	529,653

(*Source*: THE TRADE OF CHINA, statistical series)

Japanese tung tree is derived from Aleurites Cordata, a tree of the same family as Fordii and Montana, which yield the Chinese produce. The oil from Cordata is not competitive with tung oil. Since production in Japan is relatively small, the annual output in recent years only slightly exceeded 1,000,000 pounds, but the consumption of tung oil in Japanese industries is estimated at 2,000,000 to 3,000,000 pounds. Local production does not amply supply Japanese requirements, necessitating heavy annual shipments from China.

EXPORT OF CHINA TUNG OIL TO JAPAN

Year	Quantity in picul	Value in CN$
1931	8,410	321,328
1932	6,833	204,508
1933	5,932	235,508
1934	9,287	325,261
1935	7,893	361,867
1936	10,122	798,442
1937	7,467	581,896
1938	558	57,293
1939	285	38,088
1940	312	201,679

(*Source*: THE TRADE OF CHINA, statistical series)

Tung oil is employed principally in Japan for the manufacture of varnishes, the waterproofing of umbrellas and in lacquer and lacquerware industries. The Japanese paint and varnish industry has progressed considerably during the past two decades.

Denmark consumes a larger quantity of tung oil than is indicated by China's export statistics. In 1929, the consumption of oil in the Danish paint industry was 1,298,000 pounds. The Danish production of varnishes increased in value from 81,400 in 1926 to nearly $1,000,000 in 1929. Denmark, like the other European countries formerly employed linseed oil almost exclusively, but is now manufacturing tung oil varnishes in increasing quantity for both general and specialty uses. Exports of tung oil are recorded as follows:

EXPORTS OF CHINA TUNG OIL TO DENMARK

Year	Quantity in picul	Value in CN$
1931	11,911	444,569
1932	10,777	282,191
1933	6,544	258,550
1934	7,551	308,246
1935	7,960	478,242
1936	8,719	859,444
1937	4,980	431,272
1938	1,711	107,171
1939	1,220	175,096
1940	102	73,087

(*Source*: THE TRADE OF CHINA, statistical series)

China's exports of tung oil to the Netherlands are indicated in the following table. However, these figures do not show the actual imports of tung oil into this country, since there is a major difference between Chinese exports and Netherlands imports, because of a great volume of tung oil trans-shipments at ports in the Netherlands.

EXPORTS OF CHINA TUNG OIL TO THE NETHERLANDS

Year	Quantity in picul	Value in CN$
1931	45,464	1,763,748
1932	59,355	1,587,027
1933	41,140	1,308,311
1934	31,061	1,261,417
1935	20,607	1,585,064
1936	16,424	563,404
1937	6,000	235,078
1938	3,509	152,615
1939	1,059	———
1940	———	———

(*Source*: THE TRADE OF CHINA, statistical series)

The Netherlands paint and varnish industry is fairly extensive, but its use of tung oil has been restricted by a strong preference for linseed oil. In 1923, the consumption of tung oil in that industry was estimated at about 500,000 pounds. Recently it was reported that over 100,000 pounds were employed in Netherlands paint and varnish manufacture.

China exports of tung oil to Italy have shown a gradual expansion over the past ten years, in line with progress made by the Italian paint and varnish industry.

EXPORTS OF CHINA TUNG OIL TO ITALY

Year	Quantity in picul	Value in CN$
1931	5,512	137,483
1932	3,958	112,089
1933	2,645	107,817
1934	3,338	146,425
1935	5,382	328,127
1936	1,389	144,113
1937	5,208	440,808
1938	1,133	67,800
1939	1,090	100,876
1940	960	670,262

(*Source*: THE TRADE OF CHINA, statistical series)

The other countries do not play an important role in exports from China, as may be deduced from the roughly comparative ideas in the following table:

EXPORTS OF CHINA TUNG OIL TO OTHER COUNTRIES

(Unit: picul)

Countries	1936	1937	1938	1939	1940
Argentina	1,345	994	255	30	—
Australia	5,962	5,466	580	10	—
Belgium	4,608	3,355	1,541	239	23
India	815	688	556	251	355
Canada	192	414	149	—	130
Finland	749	1,055	—	52	—
Indo-China	595	517	2,052	11,782	1,355
Norway	6,829	3,805	299	20	—
Spain	213	905	—	25	—
Sweden	6,245	4,218	1,451	940	102
Netherland Indies	49	235	—	—	203
New Zealand	224	223	—	—	—
Poland	256	85	—	50	—
South Africa	63	197	—	51	18
U. S. S. R.	—	711	—	—	—
Burma	—	—	—	—	18,240
Phillipine Is.	—	—	—	1	—
Siam	—	—	22	2	—

(*Source*: THE TRADE OF CHINA, statistical series)

CHAPTER III

TUNG OIL INDUSTRY DEVELOPMENT IN THE UNITED STATES

1. *Introduction of Tung Oil into the United States*

The production of tung oil is considered one of the infant industries in the United States. Tung oil trees were introduced into the United States through the efforts of the Office of Plant Introduction of the Department of Agriculture. The first tung seeds were sent from China by L. S. Wilcox, Consul General at Hankow, to someone in California in 1903 and 1904. A small quantity of seed was sent to Washington, D. C. in 1904, and was distributed by the Department of Agriculture among various experiments in the more temperate sections of the country. A large shipment of seeds was received in 1905, and these were planted on the experimental farm at Chico, California. A quantity of seedlings resulted from this planting, and in 1906, these seedlings were distributed to state experimental stations in the southern states, Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina and Texas; to a few private experimenters, and to public parks on the Pacific and Gulf Coasts.

It has been firmly established that this tree will grow successfully only in a limited area, embracing the extreme southeastern center of Georgia, the upper third of the state of Florida, and a narrow belt extending only 50 to 100 miles north of the Gulf of Mexico in Alabama, Mississippi, Louisiana and Texas.

The American tung oil industry took a definite step forward when David Fairchild of the Bureau of Plant Industry aroused the interest of the Paint Manufacturers Association and National Varnish Manufacturers Association in the possibilities of tung culture in the United States. Under the sponsorship of these two associations, a survey was made of the commercial possibilities of tung cultivation in the South. An optimistic report was made in 1921, and in 1923 the American Tung Oil Corporation was organized as a subsidiary of the American Paint and Varnish Association. The Corporation

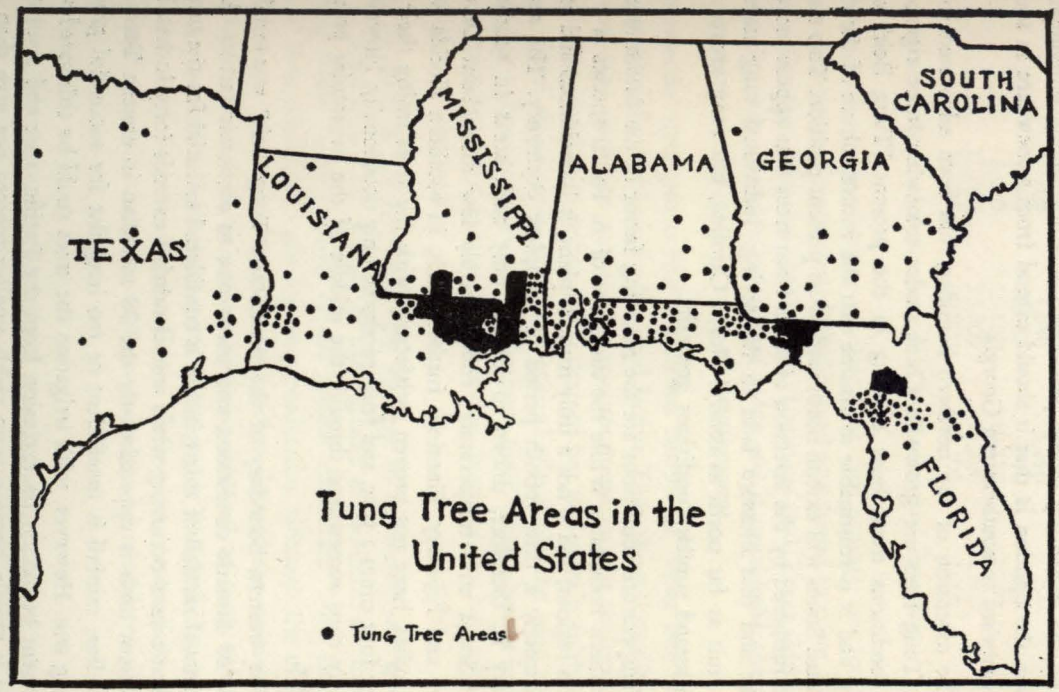
was a non-profit venture financed by leading paint and varnish manufacturers to foster the commercial growth of tung trees.

Numerous experiments in tung tree plantation are now in progress. The University of Florida has been carrying on experimental work in the area of Gainesville. The Department of Agriculture has established a number of laboratories in the tung region and are investigating all phases of tung culture and the processing of the nuts. The Bureau of Plant Industry maintains five stations for its experimental work, all located in tung producing areas, in Beltsville, Md., Bogalusa, La., Gainesville, Fla., Cario, Ga., and Fairhope, Alabama. The Bureau of Agricultural Chemistry and Engineering maintains two field stations, one at Gainesville, Fla., and the other at Bogalusa, La. in addition to the work they are doing in Washington on tung investigations. The problems concerning the experimenters are: the controlled drying of tung fruit by kilns and other means, and the possible development of a solvent process of extraction. The Department of Commerce, through its Chemical Division, has been studying the economic and commercial aspects of tung oil development, and has issued various reports detailing the progress of the industry. Much of this material is available in published form for those who wish to make a more thorough study of the various problems in tung culture and oil production.

At the early stage, although considerable experimental work was conducted in the southern states and there was increasing interest in the cultivation of tung trees in this region, in addition to the legitimate large-scale experimental plantings made by financially stable organizations, other companies, whose main object was to sell their stock, were victimizing many small investors. The tung industry, as a commercial enterprise only, had its inception in 1925, and since that time American tung acreage has rapidly expanded.

2. *Boundaries of the American "Tung Belt"*

The three major centers of American tung production in the "Tung Belt" according to G. F. Deasy: (1) northeastern Florida and the adjacent extreme southern border of Georgia, (2) extreme southern Mississippi and Alabama, and adjacent parts of southeastern Louisiana and western Florida and (3) a small center in southwestern Louisiana. The Mississippi portion ranks as the most outstanding.


TEXAS
LOUISIANA
MISSISSIPPI
ALABAMA
GEORGIA
SOUTH CAROLINA
FLORIDA
Tung Tree Areas in the United States
Tung Tree Areas

The northern margin is determined by temperature conditions. Winters must necessarily be mild, lest the warmth-loving tung tree be killed; late spring frosts must be infrequent to keep the blossoms from being destroyed. The lowest temperature for tung tree survival has not been ascertained, due to the high percentage of immature trees, inherently more susceptible to cold, and the variability in the period of dormancy among individual trees. However, the opinion is that it should extend from somewhere in southeast Texas eastward to southeastern Georgia.

The extension of the northern boundary has been advocated in some circles. Tung trees are grown in China under somewhat more rigorous climatic conditions than those existing in the present "Tung Belt" of this country, and it is reasonable to assume that the future culture of the crop in the United States will extend northward of its present position. This tendency will be furthered by the selection of seeds from trees that appear more cold-resistant and that blossom later in the spring. Individual tung trees have borne fruit as far north as central North Carolina, but tung groves would not withstand similar conditions generally.

Temperature conditions are the resolving factor in the determination of the southern boundary. While the tung tree of A. Fordii species is a native of warm regions, and is not a truly tropical plant, it is deciduous and requires approximately a three-month period of complete dormancy. The southern boundary is, therefore, drawn to include only such areas in southeastern United States with temperatures comparatively low throughout December, January and February. Plantings further south, in southern Florida and the West Indies, have not proven satisfactory with the trees losing their leaves three or four times a year, and fruit produced only occasionally. However, the boundary runs somewhere through the middle of the peninsular portion of the state.

The western boundary of the American "Tung Belt" was established because of climatic conditions, and partly due to economic factors. A minimum annual rainfall of thirty inches is considered essential for the tung tree, with best results occurring when annual rainfall exceeds forty inches. Hence, the western limit is approximately the 98 meridian in eastern Texas. West of that line, rainfall is insufficient or too irregular for successful growth of the tung tree. However, with irrigation the trees could be cultivated west of the present boundary. Its exclusion from the Pacific coast and southwestern regions is chiefly because tung yields smaller returns per acre than several other comparative irrigated orchard and vegetable crops, despite original over-optimistic reports.

TUNG NUT PRODUCTION IN THE UNITED STATES

(Unit: tons)

Year	Florida	Mississippi	Louisiana	Georgia	Alabama
1939	550	425	150	15	20
1940	4,700	3,700	1,200	1,200	200
1941	2,250	3,700	1,800	650	350
1942	3,700	7,200	4,000	950	500
1943	700	1,940	3,260	200	100
1944	7,000	10,630	7,550	800	700
1945	8,400	15,690	10,750	1,100	1,140
1946	15,000	23,800	15,200	1,800	1,600
1947	16,000	28,000	18,700	2,000	2,000

(*Source*: Dept. of Agriculture, Bur. of Agricultural Economics)

Although the preponderance of early tung tree acreage was located in Florida, as interest was awakened, desirable land was found in other parts of the South, Georgia, Alabama, Mississippi, Louisiana and Texas. Mississippi represents the most extensive cultivation today and is considered one of the outstanding centers of American tung oil development.

Commercial tung production within the American "Tung Belt" is still further restricted by certain more localized factors. First, the soil requirements of the tung tree are rather exacting for maximum output, the preferable soil being a fertile sandy loam that is easily drained but will remain fairly moist. In China, where many types of soil are utilized effectively, the tung tree has produced fair returns under conditions far from ideal. Tung planters in southeastern United States have found it profitable, however, to use only those soils best suited to the tree.

Air drainage is another important element to be considered. It is advisable to plant tung trees on hilly or sloping land to minimize the threat of late spring frosts. Large portions of the present American "Tung Belt" are plains and thus considered unfit for tung production, although the tung tree will grow in any area with some degree of success. It has been estimated that 80 percent of the soil of that part of Florida devoted to tung culture, is economically unsuited because of poor drainage, or susceptibility to frost arising from land or surfacing conditions. Equivalent proportions of the potential tung areas of the other Gulf states might be considered unfit for similar reasons.

3. *The Growth of the Tung Oil Industry*

Large-scale specialized enterprises have predominated since the inception of tung tree cultivation, as a result of the nature of the interests concerned

with tung promotion. Paint and varnish companies interested in developing an independent supply of tung oil were among the first large-scale growers. Lumber compaines, seeking to utilize cut-over timber land, were also important planters, especially in Mississippi ,where some of the largest enterprises are to be found. People deriving the major part of their income from other sources, often took up the growth of tung as a hobby or as a means of income tax evasion. Real estate dealers and professional promoters seeking to capitalize on the public interest in tung oil and on widespread, exaggerated hopes for quick profit, also played an important part in expanding tung acreage. Small investors, too, were drawn into the tung business through the subdivision of larger orchards. In many cases, these small investors were absentee landlords who were in no position to supervise the work in their small orchards and who knew little of the existing methods practiced in them.

Tung growers in the United States can be classified into the following groups: (1) paint and varnish manufacturers, (2) people receiving their principal income from farming, (3) gentleman farmers, (4) lumber companies, and (5) promotional farmers. Over half the present tung acreage is controlled by gentleman farmers, while a fifth of the total acreage has been developed by lumber companies as a means of utilizing cut-over wasteland.

Large growers would seem to have the advantage for profitable production, because of the economy of large-scale operation, and the fact that they usually have sufficient capital to withstand the first five non-productive years.

For almost fifty years the United States government, private enterprises, chemists and plant experts of the paint and varnish industry, have all contributed money, time, training and experience, to develop this new industry. It was stated in the early stages that around $1,000,000 would not cover the outlay for the study of the tung tree, its plantation, habits, characteristics, demand for nourishment, the effects of the fertilizer upon leaf and fruit bud, groves already planted, seeds collected for extensions, and plants from which the oil is finally extracted.

The first commercial plant for the pression of tung oil was established at Gainesville, Florida, in the fall of 1928. In 1932, resulting from the 1931 crop, the first tank car of American-produced tung oil rolled out of Gainesville, enroute to a paint manufacturer in the north. This car contained 64,000 pounds of oil and was followed later in the same year by a similar shipment. In 1933 there was no production of tung oil, due to adverse climatic conditions, but in 1934 between 300 and 400 thousand pounds of oil were

produced. A late spring frost when the trees were in blossom ruined the 1935 crop. The 1936 yield was estimated at about 2 million pounds; but frost damage again caused losses to the 1937 crop, and reduced oil production to one-half million pounds. In 1938 production increased to 3 million pounds, but weather conditions in 1939 reduced the output to only 750,000 pounds. Since 1941, the production has been increasing steadily.

TUNG OIL PRODUCTION OF THE UNITED STATES

(Unit: pound)

Year	Quantity
1941	2,533,000
1942	2,290,000
1943	5,310,000
1944	2,558,000
1945	10,353,000
1946	11,046,000

(*Source*: Bureau of Census, U. S. Dept. of Commerce)

The United States began producing tung trees seriously in the period when Japan had the Chinese coast blockaded, and as a consequence the tung nut output jumped from 1,160 tons in 1939 to 37,000 tons in 1945. And in 1946, it hit 66,000 tons. Prior to that time, the tung tree had been used largely for nursery purposes, although the tung crop had gone primarily to the mill in the last fifteen year period.

The first tung oil mill in the United States was established at Gainesville, Florida, in 1928. As late as 1935, there were only two mills in existence in this country, the second located at Bogalusa, Louisiana. At present there are eleven tung mills in the United States in the following locations: Gainesville, Fla.; Bogalusa, Covingtion, and Franklinton, La.; Brooker, Capps, and Cairo, Ga.; Heleyfield, Lucedale, Piccayune, and Richton, Miss. All eleven mills are small, although comparatively larger than the native mill in China.

Oil production has increased rapidly during the past few years. However, the American crop has only recently begun to furnish an appreciable part of the United States consumption. The tung oil industry in the United States, starting strictly with the scientific approach, is entirely machinized. Better strains of tung trees have been evolved through research in the United States, the Chinese problems of the prevailing ignorance of the growers and the wild state of the trees were non-existent. Greater care is exercised with the tung groves in the United States than in China. In this country tung trees are on the whole cultivated over wide areas to promote proper growth. While it is true that the tung tree requires less attention and care than the citrus trees,

nevertheless it cannot be neglected if the highest yields and longest productive life of the trees are to be expected. More fertile soils are devoted to the tung crop in the United States, with a resulting higher yield per tree and per acre. Superior pressing methods are employed in the United States, producing a better quality oil. Crude native pressing methods in China produce a dark oil with much free acid. American pressed oil is lighter in color and almost neutral in reaction, and consequently sells at a premium of several cents a pound. Also American mills extract more oil from the same amount of seed.

The development of the tung industry in the south promises to furnish at least a partial answer to several of its economic problems: Tung culture will diversify agriculture and give rise to a more balanced agricultural economy so vital to this region. The vast and otherwise useless cut-over southern pine lands will become lucrative through tung tree cultivation. The southern farmer will find tung profitable since it is practically devoid of insects or fungus diseases; it can utilize the hillsides and irregular areas unfit for general crops; harvesting can be prolonged; characteristically non-perishable, the dried fruit can be retained for sale at maximum market prices; finally, the demand is apparently unlimited. The milling industry should develop considerably as tung groves increase in volume. Abundant supplies of tung oil, turpentine, and resin, should provide an impetus toward the development of the industry. Tung press cake has proven itself valuable as a fertilizer and would reenforce considerably the supply of the greatest fertilized consuming region of the United States. In addition, tung trees are highly decorative in character and produce beautiful blossoms. They might enhance the scenic attractions of the south for the tourist trade.

4. *Future Possibilities*

The future growth of the tung oil industry of the United States will be decided by economic factors. Predominant is an important technology, both in the orchard and the extraction plant, but only as it tends to affect prices, incomes, and costs. The profitableness of the industry is determined by the relations among those latter factors.

With the price in 1946 at or near the ceiling price of 39 cents a pound for the oil, in drums at New York. High prices are the result of a war-stimulated demand that could be satisfied only slightly with the domestic production plus the stocks on hand, and could not be satisfied at all by the supply from China or other sources, since imports virtually disappeared during the war. With the return of normal conditions, China's tung oil has been re-

appearing in large quantity and its weight again tends to determine the market. The result brought about a drastic fall in prices from their wartime levels.

Costs are so much at variance in the industry that no overall picture of potential profit is possible. The original land investment can obviously be very different in different parts of the tung belt. The Farm Credit Administration, in a 1935 survey of 53 orchards in the tung belt oil industry, found that the average cost of planting an acre with tung trees was $18.87 in Florida, $11.43 in Georgia and Alabama, and $4.45 in Mississippi and Louisiana. Variations among individual orchards were even more startling, ranging from 40 cents to $52.55. Planting methods and tree costs—from 1 to 25 cents per tree—accounted in some measure for these differences.

Repeating this study on a basis of 41 groves, the total per acre costs for tung orchards from planting to the end of the fifth year, when the trees are in commercial production, were as follows: $55.70 in Florida, $24.75 in Georgia and Alabama, and $18.75 in Mississippi and Louisiana. Variations undoubtedly occurred due to the amount of cultivation practiced, the quantities of fertilizer used, the use of zinc sulphate to counteract bronzing, and the degree to which intercropping was practiced.

Few tung orchards from six to eleven years old were in existence when the 1935 Farm Credit Administration study was made. It was therefore impossible to make any precise estimates of profit or loss. On the basis of seven farms in six states, however, total costs per acre for the 1934 growing season being found to average $20.46 for the same group of farms, total returns per acre were found to average only $5.99. Growers thus realized a net loss of $14.47 an acre on the average, the average yield being only 343 pounds of whole fruit an acre. Not all these orchards showed losses, however, one of them realizing a net profit of $9.90 an acre, and another net profit of $21 an acre. Some well-managed orchards yielded average net profits amounting to $36 an acre for the period 1941 to 1945.

Price fluctuations, although affecting all producers, have their most erratic effect on growers, because of those advances in cost and irregularities of yield. A price that would yield a substantial profit to one grower might result in a disastrous loss to another. This highly speculative characteristic, one that still marks the tung industry, is the cause of many paradoxical statements. One grower will say that "tung is the most profitable thing you can put into the ground," where another may have only recriminations for ever having embarked on such an enterprise.

In view of the great variability of net returns to growers, it would seem that those growers who have well-located orchards and heavy-fruiting trees, and who practice the most economical methods of tree culture and harvesting, will be able to face the uncertainties of the future with confidence. Growers are paid a price for their whole fruit that varies with the price of the oil. The growers therefore, must be prepared to absorb the impact of both low yields and low prices. That they also get the advantage of high yields and high prices is equally true. All this is merely to say that the growing of tung is still a speculative enterprise.

However, for the United States, the tung oil industry is still in a pioneering stage, the mistakes that arose from early conditions will continue to be made, although on a diminishing scale. Development will be furthered by the scientists whose patient investigations in all phases of the industry are providing the foundation of knowledge on which success can be built. It is true that "consideration should be given to the fact that tung oil production in the United States is yet far from universally successful and money put into it should still be regarded as a speculative and not as an investment".

CHAPTER IV

TUNG OIL PRODUCTION IN OTHER COUNTRIES

In addition to the commercial tung producing countries of China and the United States, there are other countries scattered throughout the world actively experimenting to determine the feasibility of local tung tree production. Certain Latin American countries, like northern Argentina, eastern Brazil and Paraguay, have been more successful with the commercial plantation.

Next to the Latin American countries, the important plantings to date have been carried on in Europe and in other parts of the world. Experimental work is currently in progress in New Zealand, Australia, India, Malaya, Burma, Union of South Africa, Cyprus, the Netherlands East Indies, Southern U. S. S. R., and Japan.

None of the above mentioned countries have attained any importance as a producer, although preliminary reports appear promising. Certain handicaps not affecting Chinese or American growers, exist in these countries: they lack the superiority of an early beginning so vital to China; the capacity for mechanization comparable to that of the American industry is lacking; and their domestic markets are not as extensive as those enjoyed by the Chinese and American producers. However, as the uses of tung oil increase, the European demand for tung oil will undoubtedly increase, and some of these countries stand a chance of becoming significant tung oil producers in the near future.

1. *Brazil*

Brazil is now destined to become China's chief competitor in the world market in vegetable oils. In the tung oil trade, she made remarkable headway through the introduction of Oiticia oil, another drying oil, and she is now making strenuous efforts to cultivate tung trees. Brazil's commercial planting of tung trees started about 1929; the original plantings were in Sao Paulo State, and by 1935 plantings had extended to northern Parana and the Rio

Grande de Sul. For the next decade plantings continued at an accelerated rate, reaching an estimated 3,840,000 trees in 1946, of which approximately 40 percent were at the producing age. The early expansion was confined to the State of Sao Paulo, but it was soon determined that both the climate and the soil of northern Parana were more desirable for the tung tree, with the result that Parana is now the leading producing state. Present plantings in Parana are estimated at 2,000,000 or slightly over one-half of the total plantings. Experimental plantings have been made in many other states but without success. Failures were also experienced with plantings in the northern part of Sao Paulo State. It is the belief of those engaged in the growing of tung that there is not sufficient season differential in the regions that failed to meet the inherent requirements of the trees.

Various industries in Brazil are now consuming tung oil at the rate of approximately 100 metric tons per year. The principal users of tung oil in Brazil are paint factories and industries incorporating insulating material in their products.

There is no record of imports of tung oil into Brazil. It is quite possible that small amounts were imported under the classification of miscellaneous oils before the development of the tung plantation in Brazil, but it is not believed that there have been any imports since 1938. In addition, there are no recorded exports of tung oil. Exports being made are listed in conjunction with other oils as "unspecified oils". It is reported that exports for 1946 were slightly less than 100 metric tons. Since the beginning of 1947, 130 metric tons were purchased and shipped by the United Kingdom. Exports made during 1946 were principally confined to European countries, but amounts and the receiving countries are not a matter of record.

It is realized that the estimates of production, domestic, and export, are unbalanced, but it should be borne in mind that the industry is new and trading practices are not established. During 1946, it was estimated that the amount available for export would be 300 metric tons. The immediate future is directly dependent upon the 2,300,000 trees already planted which have yet to produce. Many are also on better land and in more desirable climatic zones than the original plantings. It is estimated that the potential oil production possibilities of these trees is about 2,500 metric tons. New plantings are continuing but at a diminished rate.

2. *Argentina*

Plantings of tung trees in Argentina, although still in an experimental stage, are exhibiting rapid growth, and further interest is being manifested in their extended development in the country. The first attempt was made in 1928 by the North Eastern Railway at its farm at Pindapoy, Territory of Misiones, and now there are about 107,000 acres of the seeds being developed there. Included are 10,500,000 trees from 1 to 15 years old, between 3 and 4 million of them currently producing tung nuts. Total production of tung oil in 1947 was estimated to range from 3,500 to 4,000 metric tons. Current domestic needs are about 500 tons of oil a year. Paint and varnish manufacturers are the chief consumers of tung oil.

Tung oil is not imported in Argentina. In 1946, 1,625 metric tons of tung oil were exported, most of it to the United States, representing an increase over the previous year, and expansion together with domestic production was anticipated.

3. *Paraguay*

Considerable interest in tung tree cultivation has manifested iteslf in Paraguay within recent years. The first attempt was made in 1928. Tung trees planted in Paraguay are located in certain regions of the Chaco, areas in Central Paraguay, and in the area surrounding Encarnacion in Southeastern Paraguay. Trees of the Aleurites Fordii type are grown almost exclusively, as this type is most adaptable to the climatic conditions of the country.

There are almost two million tung trees now under cultivation in Paraguay, with an estimated total of 5,500 acres. Approximately one half of the total of trees planted are bearing fruit, and, as the industry is comparatively new, greater production is expected within the next few years. Total estimated production of tung oil in 1947 is reported at over 600 tons, but it may develop as a side activity of small landowners, with the commensurate increased volume of production.

4. *New Zealand*

The first plantings of the tung tree were made in New Zealand with Chinese seed imported privately and grown solely for ornamental purposes.

It was not until 1928 that the first supply of seed was forwarded to New Zealand for experimental purposes. The districts in New Zealand in which tung trees may be grown are limited to the warmer sections of North Auckland, the Bay of Plenty, and in the area of Gisbone and Nelson. The climate of North Auckland being temperate, both A. Fordii and A. Montana could undoubtedly be grown on a commercial scale. All tung trees growing in New Zealand were produced mainly from seed imported from China, Florida, and Australia; only a small number were produced from locally grown seed borne on individual trees in some of the earlier plantings. Companies promoted for the establishment of tung groves commenced operations in 1929, and these were followed by other companies formed in the succeeding years. Those in operation may be classified according to ownership — company-owned groves, and private plantings.

The majority of the tung in New Zealand was planted in the year 1931. Generally those attempts have been described as failures. The principal reasons for the failure of the trees were the unsuitable nature of the soil in which they were planted, the absence of adequate shelter, and the climatic conditions.

In 1937, it was estimated that there were 5,580 acres planted with 390,000 trees, although in mid-1940, the acreage was considered to be only 2,600 acres. The only promising plantation was reputed to belong to the New Zealand Tung Oil Corporation situated at Awarua, Auckland. The oil yield from the plantations of the Corporation amounted to only 245 gallons in 1939.

The rapid development of the tung oil industry in China and the expansion of the use of the oil in the United States, were detrimental to one of the most important industries in New Zealand — the production and export of Kauri Gum. Prior to the introduction of tung oil into the U. S., this product was one of the leading raw materials, together with linseed oil, for varnish formation. Imports of Kauri Gum into the United States in 1937 amounted to 2,137,207 pounds, whereas such imports in 1938 dwindled to 767,014 pounds.

5. *Australia*

It is probable that the first interest in planting tung trees in New South Wales was developed at Pennant Hills, 18 miles from Sydney, in

1926, while the first experimental plantings at Queensland were made by the Queensland irrigation authorities in 1927. At present, the area of tung cultivation in Australia is centered in the coastal regions from Sydney north to Rockhampton, Queensland, in the vicinity of Copp's Harbor district.

Estimates indicate that approximately 1,500 acres of the Aleurites Fordii type of tung tree were planted in Australia. The age of the trees ranged from 5 to 15 years, and the oldest are still bearing. In 1946, the total production of tung oil was 20,000 pounds and practically the entire output was processed by a mill located in Sydney. The annual requirements of tung oil in Australia average approximately 1,100,000 pounds. It is reported by the Sydney Technical College that the Australian oil is on par with the Chinese oil in quality. The most suitable locality in Australia for the cultivation of tung trees is considered to be the east coast, where crops with a yield of oil account for half of the weight of the fruit reported there. The tung oil interests in Australia believe that, should success attend their efforts to establish tung oil plantations in north Queensland, the demand in Australia could be supplied, and further outlets might be found in New Zealand, Great Britain, and countries of continental Europe.

6. *India*

India's limited tung production is confined to certain tea plantations in Assam and north Bengal. The type of tung trees chiefly cultivated in India is the Aleurites Montana, as this type thrives best in northeast India. In 1939, there were only 900 acres of tung trees in Assam and Bengal, but by 1946 acreage had increased to about 4,000. There are also a few experimental plantations in Bihar and the Punjab. Practically the whole of India's tung production is crushed by the Gourepord oil mill in Naihati, Bengal. Tung oil output for 1946-47 was estimated at 80 tons.

India consumes 250 to 350 tons of tung oil per year, mainly in paint manufacture. Tung oil is imported into India principally from China. The amounts are not reported in "Accounts Relating to Sea-Borne Trade of British India". Considering the difference between reported domestic consumption and production, it would appear that imports amount to 170 to 270 tons a year.

7. *Union of South Africa*

Tung oil cultivation began with a small importation of seeds into the Union in 1932. Five years later, more seed was imported and trial plantings were established at the government's sub-tropical Horticultural Research Station at Nospruit and in other areas in the Transvaal, Natal, Cape Province

and Swaziland. By 1941, many groves exceeding 2,000 trees each were planted with an aggregate of more than 60,000 trees. Within the last six years, plantings have increased considerably and it is estimated that there are now approximately 500,000 tung trees planted out as orchards in the Union of South Africa and Swaziland. However, the Research Station has concerned itself with tung oil research, mainly because it felt that certain areas, particularly in the Transvaal lowveld and Natal, may prove extremely suitable for the commercial production of this crop. Until recently only Aleurites Fordii seedlings were planted as this species thrives best in milder areas where a fair amount of frost occurs during winter but is absent in spring. As a result of experiments, the plantings of A. Montana, which thrives in the slightly warmer areas, has come into favor.

The oil from all nuts produced in the Union of South Africa and Swaziland is extracted by two companies—Epic Oils Ltd., Johannesburg, and Cotona Oil Ltd., Germiston. In 1946, because of the drought, the total production of both plants was less than 100 tons. Epic Oils has a production capacity of 400 short tons and Cotona Oils 750 tons monthly of all kinds of oil, both being manufacturers of edible oils primarily. Tung oil is therefore produced only as a sideline, but can be developed as production of tung nuts increases. At present, Epic Oils processes about 60 percent of the Union's production of tung oil, while Cotona Oil processes the other 40 percent.

Domestic consumption is limited entirely to use in paint manufacture, and the annual consumption is estimated at 250 short tons. Imports are not shown separately, but it is estimated that imports of tung oil amounted to about 200 tons in 1946. There are no exports of tung oil from this Union.

8. *Burma*

In Burma tung trees grow uncultivated, and it was not until 1927 that attempts to plant them on a scientific proposition were made, principally in the southern Shan States. Cultivation gradually extended towards the Northern Shan States, with this cultivation a strictly commercial idea. To further this end, a number of British paint and varnish manufacturers, founded a limited liability company in April 1930 under the title of Tung Oil Estates, Ltd., original capital of 50,000 pounds subsequently increased to 150,000 pounds. The company's plantings totalled 4,000 acres by the end of 1938, chiefly centered in the State of Hsum Tsai, while extensive plantings are under consideration. Another company, Shan States Tung Development, Ltd., capitalized at 10,000 pounds, was established in1935, and by the end of 1938, it had 1,500 acres planted in addition to about 1,200 acres under village

cultivation. The latter plan was considered to be very encouraging, because it augmented the income of the farmers. Shan States Tung Development, Ltd., however, arranged with the village to purchase the entire output exclusively at fixed prices.

The Tung Oil Estates, Ltd., works in close cooperation with the Imperial Advisory Committee on Oils and Oilseeds, London, which established a special sub-committee in 1929 to promote tung tree cultivation and tung oil production in the Empire countries. With that end in view, the London office of Tung Oil Estates, Ltd., in mid-1936 undertook the purchase of tung nuts produced in Burma as well as in other Empire countries, at prices in ratio of 5:1 for the oil and nut respectively, c. i. f. London basis. The arrangement was on a one-year basis, but no data could be secured covering subsequent developments.

9. *Cyprus*

A plantation of tung trees, variety A. Fordii, was planted by the Cyprus Agricultural Department at Polis in 1930. Early plantings were made in 1922 and 1923, but expansion was slow. In 1936, the yield from tung plantation rose rapidly under irrigation, thereafter declined considerably when irrigation was stopped. It was said that Cyprus had shown a better yield than the United States. The Cyprus plantation yielded 798.84 pounds of fruit per acre when the trees were six years old, and the average yield of the 7th-9th years inclusive was 633.36 pounds of fruit per acre. While in the United States the average yield of 562 acres of six year old trees, however, was 278 pounds per acre; the average yield of 300 acres of trees 7-11 years old was 343 pounds per acre. This comparison, although it must be accepted with caution because the Cyprus plantation probably received better treatment than the average American one, is nevertheless not to b ignored. It appears that the Agricultural Department's demonstration plot at Polis served its purpose, and it is evident that tung trees now may be grown more satisfactorily in Cyprus.

Tung oil tree growth in Cyprus can only be regarded as a sound financial proposition if it can be shown to be at least as profitable as other tree crops requiring the same attention and irrigation. At present, the tung oil is not produced on a commercial scale in this country. Efforts made just prior to the war, to establish the crop on an economic basis, failed in some cases due to non establishment of trees after planting out, and in others due to lack of interest.

10. *Malaya*

The experimental station established at Kuala Lumpur in 1914 represented the first attempt to cultivate A. Fordii in British Malaya. Encouraging

at the outset, these plantings developed unsatisfactorily and were abandoned. A. Montana was tested at Kuala Lumpur in 1920 and on the government plantation at Serdang in 1924. These trials convinced Malaya that both species are unfit for commercial production on their plains. Nevertheless, further experiments are being conducted at the Cameron's Highlands plantation, at an elevation of 5,000 feet, and it is possible these efforts may meet with some success.

11. *Kenya*

Early trial plantings in Kenya with both A. Fordii and A. Montana at altitudes over 5,000 feet, resulted in failure of seed to germinate rapidly, and growths were successful only at Nairobi. Owing to difficulties of procuring good seed, the nut yields were retained for further plantings within the country. Trial extraction by the Imperial Institute of the Kenya Colony produced seeds with chemical properties in the oil comparable with the best China tung oil. Further efforts in experimental plantation were carried out, and even an important coffee planter in Kanya planted 200 acres of his estate in tung trees. Perhaps Kenya can possibly develop its tung tree plantation in future years, as a result of these experimentations. "During the past 20 years both A. Montana and A. Fordii have been extensively tried in Kenya, but apart form one or two extremely small isolated areas the results have not been encouraging. The position today, therefore, is that there are no commercial plantations in Kenya and neither is there any marketing organization for the nuts."

12. *Netherlands East Indies*

Tung tree experiments in the Netherlands East Indies were first conducted during 1929 and 1930 at the government experimental station at Buitenzorg, Java. Due to the suitable soil and climatic conditions existent in Java, A. Montana and A. Fordii are imported from Central and South China for plantation purposes. Seeds of A. Montana were found to grow more rapidly than those of A. Fordii, and experiments in grafting the two species were undertaken in early 1931, in hopes of combining the rapid-growth quality of A. Montana with the reputedly better oil quality of A. Fordii. No reports on this grafting will be released for several years, at least not until the fruit appears, although it has been said that the grafts are progressing nicely. Government authorities considered the Netherlands East Indies natural terrain for tung oil production, and extensive plantings are in order when the experiments disclose the desirable species to cultivate.

13. *U. S. S. R.*

Tung cultivation is conducted in Russia along experimental lines. The locations of tung tree orchards are confined to Abhazia, a district in Georgia, south Caucasus, facing the Black Sea. The first tung trees were planted in the Batum Botanical Garden in Russia in 1930; and these remained for some time the only speciments in the country. During the first Five Year Plan, the insistent demand of the paint and varnish industry aroused interest in the product of these trees; and in 1934 there were 700 hectares of young tung trees in the Soviet Union, with 341 hectares (one hectare comprises 2,471 acres) more to be planted during the year. Nurseries for the trees are also being established. The paint and varnish industry, and other branches, require the produce of 15,000 to 17,000 hectares of tung plantations. The importance of developing this field is recognized by the Soviet Government, and a special "tung oil Bureau" has been set up in Batum to manage the existing plantations, to study the raising of the trees and the uses of the oil, and to extend the area planted, both in experimental stations and through the collective and individual farms. In 1939, the total acreage of Russia's plantings was reported at 15,800 hectares. According to data displayed at the All-Union Agricultural Exhibition in Moscow, nine hectares produced 3,378 tons of fruit. The entire experiment is being carried out with strictly scientific methods as regards the full selection of soil and seeds. The seeds were mostly obtained from the United States, during 1935, 1936, and 1937, a special committee of Russian specialists spent considerable time in the American Tung Belt, studying soil, planting, collection of nuts and extraction of oil. In 1937, another group of specialists on a visit to the United States shipped forty tons of nuts to Russia for planting purposes.

14. *Japan*

Japanese tung oil is derived from A. Cordata, a tree of different species but in the same family as Fordii and Montana. The producing locations are confined to Hukui, Tiba, Hyogo, Tottori, Shimane and, to a lesser extent, in other prefectures on the seaboard. The annual production of tung oil in Japan declined steadily from a peak of nearly 2,500,000 pounds in 1917 to about 800,000 pounds in 1925. Before the recent war, the average production amounted to approximately 1,200,000 pounds annually, most of which is devoted to domestic uses. A crushing mill was established in Shimane prefecture several years ago for pressing oil. Local production does not meet Japanese requirements, and consequently considerable tung oil is imported each year from China.

15. *Other Countries*

There are some other countries where experiments on the cultivation of tung trees were undertaken enthusiastically, such as Rhodesia. There is one small plantation in Northern Rhodesia, this is privately owned and is situated near the Nyasaland border in the Fort Jameson district. Its survival is doubtful and there has been no appreciable production to date. In Madagascar, French forest-service authorities have recommended further experimentation, particularly with regard to the yield of oil from existing trees in this colony. In 1930 the National Fascist Farmer's Confederation became interested in the prospect of cultivating tung trees in Italy, and imported a consignment of seed for trial cultivation. A planter in Chimoio on the Beira Railway in Portugese East Africa, imported 3,000 tung seeds for plantations on his holdings. Th Belgian Congo, French Morocco and Hawaii have all imported tung seeds for experimental plantings. Falling outside the line of actual plantation, no data are available regarding the results of these experiments.

CHAPTER V

FUTURE PROSPECT OF TUNG OIL IN THE INTERNATIONAL MARKET

1 *Potential Market for Tung Oil*

Tung oil has recently become the outstanding export commodity of China. In 1913, it ranked eighteenth in commodities exported, representing less than one percent of China's total exports. During the past few years, China's annual export of tung oil has expanded to over 200,000,000 pounds, valued at twenty to thirty million U. S. dollars, until now it is China's foremost export item, accounting for about 15 percent of her total export.

The world demand for tung oil was never adequately met pre-war, since the consuming industries geared their production in ratio to quantities available. As a case in point, the United States normal annual requirements for tung oil surpass 150 million pounds, and Chinese imports cover approximately 120 million pounds, despite the extensive plantings that have been made in this country. Yet the United States could consume 300,000,000 to 400,000,000 pounds annually, were such amounts available steadily and at reasonable prices competitive with other drying oils.

Great Britain decontrolled tung oil in October 1947 and is gradually liquidating its governmental stockpile by stipulating that importers purchase quantities proportionate with their shipments. An acceleration of Great Britain's recovery program is anticipated in 1948, thus increasing her imports of tung oil to over 12,000 tons.

The European countries are developing into potential purchasers comparable with Great Britain. Belgium has begun producing a commodity known as "Copasen", composed of tung oil and resin imported from Japan. There is also good prospect that Germany, France, Italy and Russia will soon extend their markets to include this commodity.

The consumption of tung oil in European countries increased steadily in pre-war years, particularly in Germany, Great Britain, France and the

Netherlands. The total quantity of tung oil consumed in these and other countries approximated 30 percent of China's exports, or about 50,000,000 pounds annually. A reasonable assumption is that larger quantities of the oil would be consumed, if available at the right time and at the right price. The possible capacity was estimated at from 100,000,000 to 150,000,000 pounds annually. Under conditions prevailing before the war, the international market constituted a total requirement of 400,000,000 to 550,000,000 pounds, far exceeding the total world production.

2. *The Superior Properties of Tung Oil*

As the world became aware of the protective value of coating materials, the use of vegetable oils with drying qualities for the purpose increased and expanded considerably. The various vegetable oils were then classified into drying, semi-drying, and non-drying oils. Any vegetable oil that on exposure to air absorbs oxygen and gradually dries into a tough film when applied in a thin layer, is called a drying oil. Not all vegetable oils possess this drying property. Good drying oil not only dries rapidly on exposure to air, but the film formation is durable, waterproof and weatherproof. China tung oil, when properly treated, forms a hard film which can be ruptured only by definite pressure, and thus is considered to be one of the best-known drying oils. Many of the American paint and varnish scientists consider tung oil the most durable, waterproof and hardest of all the oils used in their industry.

Two factors create competition of similar raw materials. The qualities and properties of the material itself constitute the first requirement — whether they are such that another material or combination thereof may be substituted. The other is the economic factor—their relative values and availability at competitive prices. This will come up in further discussion.

Numerous drying oils of vegetable origin and commerical importance, are utilized in the industry. Varnish consists of four principle ingredients: oil, resin, solvent, and driers. A drying oil, as mentioned above, is one which becomes dry and solid when applied as a film, in contrast to a non-drying oil, such as peanut oil or fuel oil, which remains wet or sticky months afterwards. Varnish derives its toughness and flexibility from the oil content; consequently, the more oil employed, the more elastic the varnish film. This quality is of vital importance for varnishes used on textiles, on raincoats for example, and on exterior surfaces, as boats, wooden homes and exposed structures. Tung and linseed oils are the two important oils in the varnish industry. The following cases compare these two oils, to show the differences in results obtained:

Tung oil is the fastest "cooking" oil in common use today. To heat linseed oil to 560 degrees F and keep it at that temperature would require 4-6 hours. At the same temperature, tung oil will reach viscosity in a few minutes.

Tung oil is the fastest drying in existence. We can make varnishes with linseed oil and with tung oil, and flowouts of these varnishes will show considerable variation in drying speed. The linseed varnish will dry in 24 hours, while tung requires the short period of 4 hours.

Tung oil is the most waterproof oil known. When the above-mentioned flowouts have been allowed to dry for a few days, upon immersion in boiling water, the linseed varnish will turn white in 10 minutes, while the tung oil varnish will show no change after 30 minutes.

Tung oil forms a naturally wrinkled film. Unless tung oil is heated above 550 degrees F, a film of the oil with or without driers will dry wrinkled. This characteristic is advantageous in achieving the wrinkle finishes used on typewriters and metal furniture. The varnish is cooked at 450 instead of 560 degrees, resulting in a material which wrinkles very efficiently.

Considering all these properties, tung oil is a very economical oil even when sold at higher prices than other oils. Consider these points:

Due to its fast bodying action, its fast drying and its waterproof quality, cheaper resins can be used with tung oil with better results than will be secured with other oils containing more expensive resins.

Since other oils body so slowly, the varnish maker always bodies his oils to a high viscosity before he uses them in the manufacture of varnish. This involved prolonged cooking, which process is quite unnecessary with tung oil.

Many oils have to be refined before cooking. Raw linseed oil, for example, will form a sludge if cooked; this necessitates a refining process which adds 1 to 3 cents per pound to the cost of the oil. This is unnecessary with tung oil.

Many drying oils are utilized in present-day manufacture, to mention a few, oiticica and perilla oils, and the popular dehydrated castor oil. No replacement has yet been discovered to compare with tung oil, considering per-

formance and cost, despite years of research. American varnish technologists have some opinions on the subject:

> "There is no other oil which will successfully replace tung oil in all formulations, particularly in waterproof spar varnish. Oiticica oil and perilla oil may be used as substitutes for tung oil and linseed oil with fairly parallel results if the waterproof requirement of the varnish is not too rigid . . .enough for commercial purposes at least. The best procedure in our opinion is a mixture of tung varnishes, one constructed of tung and linseed oil base, and the other on the oiticica or perilla base. Where tung oil has ben used in combination with linseed and fish oil, a substantial amount of tung oil may be replaced by perilla oil. In other words, in paints and varnishes where waterproofness is not an essential feature but rather where commercial quality only must be maintained, substitution can be made along the line suggested. No definite ruling can be made as to the amount of perilla which can be substituted for tung oil in these paint formulations as it depends upon the formulations in question each time.
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> "It has been our experience that any kind of a substitution of linseed or perilla oil slows up the drying considerably. In other words, to substitute such oils for tung oil, the customer must necessarily be willing to accept a slower setting and a slower drying finish than is obtainable when tung oil is used. A certain amount of oiticica oil can be substituted for tung oil, but this product evidently is also scarce, and the price follows very closely that of tung oil.
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> "It was thought in the beginning that oiticica might prove to be a substitute for tung oil, experience has shown that oiticica's drying properties are between those of tung and linseed oil, but it is definitely not a substitute for tung oil."

The newest trend is the recognition of dehydrated oil as an important independent vehicle and its more frequent use. As one of the chemists stated:

> "Dehydrated castor oil is similar to tung oil in that both can yield a frosted or minutely wrinkled film when permitted to dry alone, without further treatment. This property, together with studies of their absorption of infra-red rays indicate that a large precentage of the components of the new oil are similar to those in tung oil which contributes to the rapid drying and durability of the films."

Dr. Henry A. Gardner, one of the first advocates of American tung oil production, pointed out that "at the present moment, there is an oil which very closely resembles tung oil, that can be made from castor oil. But at best, this oil cannot compete with tung oil under normal economic conditions."

In wartime, the discontinuance of Chinese tung oil shipments made research for substitutes imperative. Some of the replacement oils were oiticica oil, dehydrated castor oil, isomerized linseed and soybean oil, and the maleic chemically treated oils, fractionation oil from natural oils and fatty acids. Synthetic oils obtained by esterifying sorbitol and mannite alcohols with drying oil acids were also developed and it is believed the price factor will determine their future.

Synthesis has recently developed a rubber superior in many properties to the actual product of the Amazon or the carefully cultured latex of the Dutch East Indies, but the price of the synthetic material is so out of line that the natural product continues to dominate the market. Nevertheless, synthetic rubber is now an established fact, and the natural item will never again market at exorbitant prices. The development of a synthetic tung oil might act in a similar manner, without disturbing the use of the natural product. Attempts to produce materials by synthesis when successful, usually result in materials with additional valuable properties, which makes them additionally useful for entirely new applications, and thus extends the scope of the market for both.

3. *Stabilization of Price Fluctuation*

Under normal conditions, the price of China tung oil in foreign markets is determined by the cost of production, processing, transportation, and marketing on the part of China, as well as by the rate of tariff duties and the cost of handling on the part of the importing countries. The fluctuation of China's tung oil price is mainly caused by China herself. As previously mentioned, Chinese tung oil, on its way from the farmer to the foreign importer, passes through a number of intermediaries who increase the cost repeatedly through speculation; on the other hand, China had some dark years for over a century, owing to domestic chaos and foreign aggression. The economic situation and transportation difficulties always affect freight charges and costs, in addition to the risks and losses involved for the dealers.

The price of tung oil is characterized by extreme instability. Over a period of five months in 1923, it jumped from 15 cents per pound f. o. b. New York to 42 cents, which represents an increase of 280 percents. The

crash from this peak was equally spectacular, from 42 cents attained in May, to 18 cents in the following month.

During that period, other competing oils were quoted as follows (per lb., New York):

Oil	High	Low	Difference
Tung Oil	42.0	15.0	27.0
Linseed oil	16.0	11.6	5.4
Perilla	16.5	13.6	2.9
Soyabean	13.0	10.0	3.0

(*Source*: C. C. Concannon, TUNG OIL)

The years 1932 and 1933 are the worst on record in the tung oil trade. While the average price in January 1932 was quoted as 6.1 cents per pound, it depreciated during the year until in December of 1932 it sold at 4.2 cents. This weak tendency existed until well in 1933. In 1934, the fluctuations in price were comparatively within a reasonable range, but in 1935 the upward trend reoccurred: from 9.2 cents in January up to 14.3 cents in March, representing a 160 percent increase in three months. The price was quoted as 17.5 cents in May, 21.2 cents in August, and 35 cents in September. The following month saw a decline to 268 percent of the September value, with the price at 16.4 cents. By way of comparison, a table of prices of competing oils during the same period, showing the violently fluctuating tung oil prices, is given below:

Oil	High	Low	Difference
Tung oil	35.0	9.2	25.9
Linseed oil	9.8	8.9	0.9
Perilla	9.7	7.3	2.4
Soyabean	12.0	9.7	2.3

(*Source*: C. C. Concannon, TUNG OIL)

The price variation in 1936 was not as severe as in the preceding years, although wide differences were noticed. In January, the average price was 13.1 cents; the market continued stable from February to August, when the level between 17.9 and 18.9 cents was reached. Thereafter, it declined to the lower level of 12.7 cents in September. The years of 1937, 1938, 1939 and 1940 passed under the shadow of the Sino-Japanese War, with tung oil prices abominably affected and fluctuating along the line between 13.5 and 26.3 cents. At the close of the last pre-war period in 1941, China tung oil price began a steady climb from 26 to 35 cents, and by January 1942, the price of tung oil stood at 38 cents, which price remained in effect through September 1946. Linseed oil, on the other hand, continued at a high of 15 cents throughout the war period, with increases to 16 and to 18 cents in September 1946. The price of tung oil was excessively high throughout the

war period, in camparison with prices prevailing then on competitive oils, due to abnormal and somewhat artificial conditions. China's exports have recovered gradually since 1947, and the price of tung oil has dropped considerably in relation with other competitive oils.

Oil	1939 Average	1947 Oct.
Tung oil	20.0	27.5
Linseed oil, raw	9.0	31.3
Castor oil, dehydrated	12.3	29.0
Oiticica oil	14.0	25.0

(*Source*: Report of International Fats & Oils Service)

Since tung oil is one of the international speculative products, industrial consumers prefer more price stable oils for quantity production, for example, linseed, soyabean, castor, and various synthetic oils, all of which prices fluctuate within reasonable limits. As an aid to the positive increase of the China tung oil trade, it is desirable that the Chinese government should adjust her foreign exchange rate from time to time, and link her export and import trade together, to keep it more in line with actual domestic and world market conditions. It is generally believed that, if shipments of tung oil from China could be regulated on a stabilized price to meet the world market demand, a better market level would be fairly maintained.

In June 1947, an announcement establishing a floor of 25 cents a pound for tung oil and 30 cents a pound for linseed oil was made by the U. S. Department of Agriculture. According to the American Tung Oil Association it was unjustified, inadequate and a threat to the tung oil industry generally. They saw no historical justification for the establishment of a price of 25 cents a pound for a superior product and 30 cents a pound for an admittedly inferior competitive material. Although they conceded that the prices of tung oil during the periods of war and reconversion were high, they maintained that the price should be stabilized at a figure fair to the consumer as well as the miller and the grower. Historically tung oil has always outsold the other oils, such as linseed, castor and oiticica, to the tune of at least a 30 to 35 percent margin in price.

The decline on China's exchange caused the Chinese trade situation to look very black. The decline in exchange forced a considerable amount of tung oil to abandon its normal channel of shipment through Shanghai, where it was constantly under Chinese government supervision, for Hongkong, where the oil was delivered by smugglers. Due to black market operations in the Chinese exchange, tung oil prices were made more unstable. The Ameri-

can tung oil producers, together with a U. S. House representative, then introduced two bills seeking under provisions of the Anti-Dumping Act that the U. S. Treasury Department withhold appraisal of a commodity offered for export to this country, when it can be proved that an American industry would be injured by the importation of such a commodity, offered at a price below the cost of production; where proof of dumping is clearly established, the United States Government may impose a tariff equalling the difference between the domestic market price and the foreign market value. After a careful investigation by the U. S. Government had proven that Chinese exporters had not offered at a price below their cost, it was evident that China's tung oil had not been dumped in the United States. Thence the investigation was officially called off in May 1948.

4. *Improvement of China's Production Methods*

The fundamental determining factors for the future of China tung oil as an export commodity, are its price and quality in relation to the tung oil and substitutes of foreign countries. If the tung oil supply remains irregular, the quality remains unstandardized and prices continue to fluctuate as violently as in the past, the tung oil will soon lose its international market. To counteract these conditions, tung oil must be produced, not as a byproduct of the forest, but as an export commodity, to insure as far as possible an even flow of oil to market, at a price which may be slightly higher than that of linseed oil but comparable with other drying oils. The quantity and quality of the oil are determined partly by the natural factors of production, such as climate and soil, in which regard China seems to have a distinctive advantage, and partly by the technique of cultivation and processing. The major lines of technical and economic improvements are better methods of cultivation, processing, and marketing.

Cultivation—Centralization of cultivation is by far China's predominant field for improvement, if she is to forward her tung oil industry to meet foreign market demands. Maximum efficiency of production, processing and marketing, can only be achieved by concentrating the particular industry in a certain limited area. Dr. Crane selected the early pecan industry in the United States as his example, since it approximates the present China tung oil industry. The pecan industry consists of many millions of nondescripts seeding trees growing in forests and fields along thousands of miles of the Mississippi, its tributaries, and the principal river of Texas, in midwestern United States. Little or no attention was given to cultural care, fertilization, disease and insect control. The nuts were harvested by farmers

for their private use, and for sale or barter with merchants and other buyers, and prices received were extremely low. The farmer received only a small fraction of their actual value, since the nuts, although of good quality, were small in size and had comparatively thick shells. Not until improved varieties were developed, and the trees were planted in orchards and given proper care in pruning, culture, cover cropping, fertilization, and harvesting, was it possible to develop an efficient and effective organization for the extension of credit for production, processing, and marketing. The farmers could obtain higher prices, and the industry increased in importance when these steps had been taken. The China tung oil industry will have to revise its procedure on a comparable scale before similar ends can be achieved.

Tung oil production might well be concentrated in certain limited areas in China where suitable soils, climate and transportation are available. These areas might be divided into districts and through governmental and farmers' organizations, large-scale cultivation might be developed. This would be possible economically if the annual production within a given area were adequate enough to supply each mill with sufficient nut produce.

Processing—Chinese farmers never receive the true value for their tung nuts, owing to the amount of middlemen and the different weights and measures used in the purchase and sale. Therefore, it is suggested that, to simplify the selling process, a national standard for commercial tung nuts based on quality be established.

Tung oil in China has always been extracted entirely by means of a wooden wedge press, and this method is still in existence today. The entire process of wedge pressing consists of cleaning, drying, and grinding the nuts, steaming the meal, forming the cake, and pressing out the oil. As far as output is concerned, efficiency is low. The continued use of these presses is far more economical and practical than would be a change-over to modern expeller mills. To date, no place in China could supply enough tung nuts to keep an expeller mill in operation, and the investment would necessarily be large, while the interest and depreciation would be high. Primarily, improvements could be made on the wedge press itself, insofar as its costs and simplicity of construction are concerned. Improvements could also be made in the methods and equipment used for drying, grinding and pressing nuts, which would in turn reduce the cost of milling and improve the quality of the oil.

For long run operation, the modern oil mill equipped with expellers should be established. The primitive Chinese wooden press offers many disadvantages: the presence of a large percentage of precipitate; the absorption of oil by the wooden press; impurities caused by the adherence of dust to the

press; waste of oil caused by the weak express; the low efficiency; the relatively small output, and the waste of time. Experiments have been conducted in the United States relative to the selection of a method of extraction. The best method found is pressing with a continuous expeller, performed with the "Andrson Expeller"; its use allows a 33 to 35 percent oil extraction from American produced nuts. This may effect a noticeable increase in both the quantity and quality of China's tung oil produce. A modern tung oil mill should always be located in a tung oil producting area where the supply of tung nuts and other oil seeds is abundant enough to maintain a normal operation of the mill throughout the year. It is always advisable to store the tung nuts in warehouses no longer than five months before processing, to avoid the oil freezing in the nuts. Transportation facilities and adequate supplies of power, water and labor, must all be considered when establishing the mill.

Marketing—Tung oil production has never been gainful to the Chinese farmer, as was mentioned before. Annually after the "Fall of Frost"— a festival in the Lunder Calendar, occuring in late October or early November by the Western Calendar—farmers begin transporting their nuts to neighboring oil mills, for cash sale or oil cake bartering. Millers, peddlers, and village oil dealers, sometimes deliver the nuts to the mills, and in addition they handle distribution of tung cake, and the collection of oil for distribution to small-town oil merchants. Since the farmers can never hope to acquire the true value of the nuts, even with skyrocketing oil prices, they see no reason for seeking loans at high interest rates for tung tree growth, especially since interest rates are alarmingly high since the last war. Consequently, tung tree plantation is considered a side line. Attempts should be made to interest the farmers in the market situation, as once they realize the crop's profit to them, they will naturally devote themselves to its cultivation, and improvement should undoubtedly follow. To further this end, a market-news, or information service, should be established, based on daily reports on conditions of supply and demand at important producing market and export centers. Such a step would be a stimulant to production, if circumstances warranted.

In conjunction with farmer instruction, the organization of tung oil millers or dealers into well-financed marketing associations would do much to promote the industry. Such groups would lessen the amount of intermediaries now handling the oil, suppress unreasonable speculation, control the price fluctuation and exercise such regulations outside the capacity of the individual. Cooperatives of tung producers financed in both processing and marketing by the association would tend to further this development.

Prewar operations in tung oil trade were mostly financed by agents or representatives of foreign importing firms at collecting centers and export ports. Upon receipt of advanced payment from forward transactions, the brokers or collectors extend credit to local dealers, who in turn reloan it to petty collectors or millers. The foreign importers had financing arrangements with the foreign banks, and the Chinese brokers were financed by both Government and private banks. Consignment of a forward sale is too risky for anyone under present-day conditions, and as a result, financing has become a grave problem for dealers and millers in the interior. Thus, the above mentioned association is very vital in its financial arrangement. Some arrangement should be made whereby exporters would make advances on tung oil orders. The assembling, refining and marketing of the oils could be financed by this means, and it might possibly lessen costs and promote more rapid shipments. The only workable procedure would be for foreign importers to issue a letter of credit for cashing on delivery of the bill of lading.

Relative to the technical problems of marketing, improvement should be made in refining, packing, and inspection.

Establishment of refineries — The primitive and uneffective method of refining should be revised. The refinery should operate on a large-scale, so that its establishment may serve for the standardization of quality, so essential to a product in international trade. As a matter of fact, China tung oil exceeds the present specifications for export oil. High quality oil frequently is mixed with low quality oil, which lowers the quality of the high grade oil. Efforts should be made to segregate different grades of oil, so that advantage can be taken of the high price for the higher quality oil.

Inspection — Testing bureaus have been established by the Chinese government for the discouragement of dishonest practices of adulteration, which have been damaging to China's commercial credit abroad. Governmental testing bureaus to prevent adulteration are in operation at Shanghai, Hankow, Chungking, Wanhsien, Canton, Tientsin, Kunming, and Tsingtao, the first five of these now testing and inspecting oil for export. In addition, two more bureaus have been recommended — one at Changsha, Hunan; and the other at Wuchow, Kwangsi, owing to the importance of these provinces as producing areas of tung oil for export.

Packaging — There is no uniformity in present-day packaging of tung oil in China, the leakage from the wooden tubs exceeding that of the commonly used bamboo baskets. The new and preferable kerosene tins and gasoline drums prevent undue leakage and, although prices have gone up sharply, their overall use is suggested to reduce losses and adulteration.

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